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# Evaluation of the Suitability of Some Cowpea Genotype for Maize-Cowpea Intercrop in Northern Ghana

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## Abstract

Council for Scientific and Industrial Research-Savanna Agricultural Research Institute (CSIR-SARI) in collaboration with University of California, Riverside phenotyped 300 Recombinant Inbred Lines (RILs) of Multi-parent Advanced Generation Inter-Cross (MAGIC) cowpea population from eight elite cowpea cultivars in Northern Ghana. Among the traits targeted in the phenotyping is extra early maturity suitable for Sudan Savanna agro ecological zone of Ghana. Ten selected extra early genotypes from the MAGIC population were intercropped with maize to identify genotype(s) that can maintain agronomic performances and grain yield. A field experiment was carried out at the Manga Station of SARI, Ghana during the 2018 and 2019 growing season to evaluate the ten extra-early cowpea genotypes in maize/cowpea intercrop. The experimental design used was split plot with three replications. The cropping patterns (row, strip and sole cropping) were assigned to the main plot. Ten cowpea genotypes (MAGIC 008, MAGIC 043, MAGIC 048, MAGIC 055, MAGIC 076, MAGIC 118, MAGIC 154, MAGIC 176, CB27, and SARC 1-57-2) were assigned to sub-plots. The results indicated that the number of seed per pod of the cowpea was not affected by cowpea genotype and intercrop pattern interaction; however, the interaction influenced grain yield, pod per plant, plant height, 50% flowering and 100 seed weight of cowpea. MAGIC genotypes, M008, M048, M055, M154, recorded higher grain yield under both strip intercropping and sole cropping. SARC1-57-2 also recorded the highest grain yield under row intercropping. M048, M055, M076, M176 and SARI's collection SARC1-57-2 were the top five genotypes in fodder production. Intercropping advantage was compared with sole cropping. Land equivalent ratio greater than 1 was observed for all the genotypes with MAGIC 048 recording the highest LER at strip intercrop. Benefit Cost Ratio also showed that there is advantage of intercropping than sole cropping.

## Keywords

Cowpea, Maize, Row, Strip, Intercropping, Monocropping

## 1. Introduction

The limited land areas are facing pressure to meet basic demands of human being for food, fiber and oil. Because of rapid human population explosion, the size of cultivable land at subsistence household level is gradually decreasing and most farmers own very small plots of land, especially in the developing countries of Asia and Africa. Hence, there is a need for increasing crops production per unit cultivated land using various techniques including multiple cropping [1]. Intercropping maize with cowpea is a common practice among farmers in Northern Ghana. Intercropping has been defined by [2] as the growing of two or more crops on the same piece of land within the same year in which their interaction promotes productivity and avoids failure due dependence on only one crop. In intercropping, there is normally one main crop which most often is cereal and one or more added crops which is a legume. The main crop is considered as prominent due to its economic benefit or food value [3]. Intercropping is an effectual and the economical production system not only increases the production per unit area and time, but also increases the resource use efficiency and economic stock of the growers [4]. Intercropping serves as a guard against total crop failure and ensuring food security [4]. Moreover, harvesting of the cowpea before the maize is due for harvesting serves as a bridge to the "hunger gap" experienced by farmers as they await the harvesting of their cereals. Despite these benefits from cowpea-maize intercrop systems, farmers still suffer from the "hunger gap". This is due to the fact that they intercrop maize with cowpea varieties that may be late maturing, indeterminate and photoperiod sensitive which may be harvested alongside the maize or even after. An example is "Kusaal Benga", a local cowpea variety, which is mostly cultivated in the Sudan Savanna zone of Ghana. However, the improved early maturing and determinate cowpea varieties available to the farmers which can be harvested between 55 and 60 days after planting are also not suitable for intercropping. This deprives the farmer's opportunity to utilize the space under the maize canopy to plant cowpea varieties that can be harvested early in the season to bridge the "hanger gap" during the growing season. Additionally, the spreading nature of the cowpea varieties used for the intercrop interferes with some agronomic practices of the farmers such as reshaping of ridges, fertilizer application and weeding.

Land equivalent ratio (LER) and benefit cost ratio help to determine the advantage of intercropping over sole cropping. Calculating of LER index is based on yield of intercrop and sole cropping. All values of LER which were more than one indicate advantage or productivity of intercrops over sole cropping. Whereas when the LER is lower than one, the intercropping negatively affects the growth and yield of the crops grown in mixtures. Benefit-cost ratio on the other hand is an indicator of relative performance of a treatment. A treatment is said to be economically viable when the benefit cost ratio (BCR) is greater than 1 [5].

The Multi-parent Advanced Generation Inter-Cross (MAGIC) cowpea population from the University of California Riverside (UCR) offer the opportunity for selection of high yielding, early and extra-early genotypes for intercropping with cereals. The objective of the study was to identify extra early maturing cowpea line(s) among the MAGIC cowpea population suitable for intercropping with maize and to identify genotypes that will give economic benefits in intercropping system.

## 2. Materials and Methods

The experiment was carried out at the Manga station of Council for Scientific and Industrial Research affiliate institution Savannah Agriculture Research Institute (CSIR-SARI), Ghana during 2018 and 2019 farming season. Manga lies on Latitude 11˚1'0" North and Longitude 0˚16'0" West at altitude of 249 m above sea level and falls within the Sudan Savannah Agro-ecological zone. The total rainfall measure during the experiment was 788.6 mm. Soil samples were taken at 30 cm depth from the experimental site before land preparation gave physical and chemical analysis shown in **Table 1**.

**Treatment and experimental design**

Ten cowpea lines (**Table 2**) from the MAGIC population were obtained from Feed the Future Innovation Laboratory for Climate Resilient Cowpea project at SARI. The maize variety used was Wang-Data which is well adapted to the Sudan Savannah Zone due to its earliness (90 days), drought and Striga tolerance.

**Table 1.** Major soil characteristics of the experimental site.

| Chemical properties | Value |
|---|---|
| pH | 5.6 |
| Total nitrogen % | 0.03 |
| Organic matter % | 0.5 |
| Available P (mg/kg) | 1.4 |
| Potassium (mg/kg) | 24.0 |
| Calcium (cmol/kg) | 0.9 |
| Magnesium (cmol/kg) | 0.8 |
| **Soil texture** | |
| Sand (%) | 83.9 |
| Silt (%) | 9.7 |
| Clay (%) | 6.4 |

Table 2. Planting materials used.

| Cowpea genotypes and Maize variety | |
|---|---|
| MAGIC 008 | MAGIC 118 |
| MAGIC 043 | MAGIC 154 |
| MAGIC 048 | MAGIC 176 |
| MAGIC 055 | CB27 |
| MAGIC 076 | SARC 1-57-2 |
| Wang-data (maize) | |

The experimental design used was split plot with three replications. Three cropping patterns, row, strip and sole cropping were used and they were assigned to the main plots. The ten cowpea genotypes together with the maize were assigned to the sub-plots measuring 4 m × 1.5 m (6 $m^2$). In the row intercrop pattern, four rows of maize were planted at a spacing of 75 cm × 40 cm, then the cowpea was planted within the inner two rows of maize at planting distance of 75 cm × 20 cm using the spaces between two maize plants in a row. The two inner rows were used for the cowpea to ensure maximum shading effect. In the strip intercrop pattern, two rows of maize and that of cowpea were planted in alternation such that there were two rows of sole cowpea followed by two rows of sole maize. In the sole cropping, the whole sub-plot was planted to maize or cowpea.

The experimental field was prepared by harrowing with tractor and later ridged with bullocks. Cowpea was planted ten days after the maize had been planted. Three maize seeds were sown at a depth of 5 cm at a spacing of 75 cm × 40 cm and thinned to two plants per stand at two weeks after planting. Ten days after planting the maize, three cowpea seeds were sown at a depth of 5 cm at a spacing of 75 cm × 20 cm and thinned to two plants per stand at two weeks after planting. Weeds were controlled by manual weeding two and six weeks after planting the maize.

Data were collected on plant height, days to 50% flowering, number of pods per plant, seeds per pod, biomass weight, grain yield and 100 seed weight of cowpea, plant height, grain yield and canopy on maize. Data were also collected on LER and BCR.

Land equivalent ratio was determined according to the formula by [6] below:

$$\text{LER} = \frac{\text{YC in mixed stand}}{\text{YC in pure stand}} + \frac{\text{YM in mixed stand}}{\text{YM in pure stand}} \quad (1)$$

where:

LER = Land equivalent ratio, YC = Yield of cowpea crop, YM = Yield of maize crop.

Benefit Cost Ratio (BCR) was calculated using the formula by [7].

$$\text{BCR} = \frac{\text{Gross Monetary Returns}}{\text{Total Cost of Production}} \quad (2)$$

The data were subjected to ANOVA using GenStat statistical software 12th edition. Mean separation was carried out using Least Significant Difference (LSD) test at 5% probability.

## 3. Results

**Influence of maize and cowpea cropping patterns on earliness and growth of cowpea.**

The results obtained showed that cowpea genotype, cropping pattern and their interactions had significant effects ($P < 0.001$) on the days to 50% flowering of cowpea plants (Table 3). Flowering date ranged from 36 - 46 days and 37 - 45 days for the year 2018 and 2019 respectively after planting. On the average flowering was late for the genotypes under intercrop relative to sole cropping. On the average it took 40 and 39 days after planting for all the genotypes under row and strip cropping pattern respectively to attain 50% flowering. It took 41 and 39 days for the genotypes under row and strip cropping respectively to attain 50% flowering and this was 7.9% and 2. 6% increase in days to flowering relative to the sole cropping.

Genotype, cropping pattern and their interactions, all significantly ($P < 0.001$) had effect on cowpea plant height. Mean plant height increased between 84.5%

**Table 3.** Effect of cropping system and cowpea genotype on days to 50% flowering of cowpea in 2018 and 2019 cropping season.

| Genotype | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| | Row | Strip | Sole | Cropping Mean | Row | strip | sole | Cropping mean |
| CB27 | 38 | 37 | 37 | 37 | 39 | 38 | 37 | 38 |
| M008 | 42 | 39 | 38 | 40 | 43 | 30 | 38 | 40 |
| M043 | 38 | 38 | 37 | 37 | 39 | 38 | 37 | 38 |
| M048 | 41 | 38 | 37 | 39 | 41 | 39 | 37 | 39 |
| M055 | 39 | 40 | 37 | 38 | 40 | 39 | 37 | 39 |
| M076 | 43 | 39 | 46 | 43 | 43 | 39 | 45 | 42 |
| M118 | 41 | 39 | 38 | 39 | 42 | 39 | 38 | 40 |
| M154 | 39 | 38 | 36 | 38 | 39 | 38 | 36 | 38 |
| M176 | 42 | 40 | 37 | 40 | 42 | 40 | 36 | 39 |
| SARC 1-57-2 | 38 | 39 | 37 | 38 | 39 | 40 | 37 | 39 |
| Genotype Mean | 40 | 39 | 38 | 37 | 41 | 39 | 38 | 39 |

2018, LSD (0.05) Intercrop = 1.00, Genotype = 2.00, Interaction (G * I) = 3.00%, CV = 4%
2019, LSD (0.05) Genotype = 1.00, Intercrop = 2.00, Interaction (G * I) = 2.00%, CV (%) = 3.5%

and 154.0% under intercropping when compared to sole cropping for 2018 cropping season and between 61.2% and 159.8 for 2019 cropping season (Table 4). It was generally observed that averaging the heights across genotypes, plants tend to be taller in the maize-cowpea intercrops than under the sole cropping with row intercropping recording higher height which was about 154% and 159.8% increment relative to sole for 2018 and 2019 cropping season respectively. MAGIC 008 produced the shortest plants when averaged across intercrop patterns for the two cropping season with SARC 1-57-2 recording the tallest of about 431.5 and 303.6 percentage increase to sow cropping in row intercrop for 2018 and 2019 respectively.

**Table 4.** Effect of cropping system and cowpea genotype on height of cowpea in 2018 and 2019 cropping season (cm).

| Genotype | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| | Row (a) | Strip (a) | Sole | Cropping Mean | Row (a) | Strip (a) | sole | Cropping Mean |
| CB27 | 48.9 (111.7) | 51.3 (122.1) | 23.1 | 41.1 | 50.1 ( 93.4) | 36.6 (41.3) | 25.9 | 37.6 |
| M008 | 41.0 (87.2) | 39.1 (78.5) | 21.9 | 34.0 | 43.2 (32.9) | 32.5 (52.8) | 22.9 | 32.9 |
| M043 | 39.5 (63.9) | 50.1 (107.9) | 24.1 | 37.9 | 60.3 (63.4) | 36.9 (64) | 22.5 | 39.9 |
| M048 | 48.0 (108.7) | 36.5 (58.7) | 23.0 | 35.8 | 48.8 (100.8) | 33.3 (37.3) | 24.3 | 35.5 |
| M055 | 55.3 (119.4) | 42.6 (69.1) | 25.2 | 41.1 | 67.6 (165.0) | 46.2 (81.2) | 25.5 | 46.5 |
| M076 | 55.1 (155.1) | 31.5 (45.8) | 21.6 | 36.1 | 55.1 (130.5) | 31.5 (128.0) | 23.9 | 36.9 |
| M118 | 77.9 (224.6) | 53.1 (121.3) | 24.0 | 51.7 | 75.6 (265.2) | 32.3 (56.0) | 20.7 | 42.9 |
| M154 | 44.5 (73.2) | 34.5 (34.2) | 25.7 | 34.9 | 47.0 (90.3) | 31.1 (25.9) | 24.7 | 34.0 |
| M176 | 54.6 (128.5) | 45.8 (91.6) | 23.9 | 41.4 | 55.3 (123.9) | 41.1 (66.4) | 24.7 | 40.2 |
| SARC 1-57-2 | 141.9(431.5) | 56.5 (111.6) | 26.7 | 75.0 | 143.7 (303.6) | 73.3 (105.9) | 35.6 | 84.2 |
| Genotype Mean | 60.7 (154.0) | 44.1 (84.5) | 23.9 | | 64.7 (159.8) | 39.5 (58.6) | 24.9 | |

2018, LSD (0.05) Intercrop = 5.971, Genotype = 6.417, Interaction (G * I) = 11.394%, CV = 15.8%
2019, LSD (0.05) Genotype = 7.475, Intercrop = 3.243, Interaction (G * I) = 12.489%, CV (%) = 18.4%

Variation a (% increase in plant height relative to sole cropping).

**Effect of maize and cowpea cropping patterns on yield parameters of cowpea**

There was significant genotype and cropping pattern interactions effect (P < 0.001) on the number of pods per plant of cowpea. The results showed that the genotypes generally produced significantly fewer pods under row intercropping than under pure stand (Strip cropping and sole cropping) (**Table 5**). Sole cropping recorded the highest number of pods when averaged across the genotypes for the 2019 cropping season which was not significantly different from the strip cropping. Most of the genotypes produced higher pod number in strip and sole cropping pattern with the exception of SARC 1-57-2 that produced its highest under row intercrop. The row intercrop recorded 31.8% and 43.5% reduction in the number of pod relative to sole for 2018 and 2019 cropping season respectively.

Although no significant genotype x cropping pattern interactions effect (P > 0.01) was observed for number of seeds per pod, there were significant differences for the genotype (P < 0.001) and for cropping pattern (P = 0.004). The highest number of seeds per pod was recorded by M154 and half of the genotypes produced 12 seeds per pod in 2018 (**Table 6**). Seed per pod recorded in

**Table 5.** Effect of cropping system and cowpea genotype on the number of pods per plant of cowpea in 2018 and 2019 cropping season.

| Genotype | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| | Row | Strip | Sole | Cropping Mean | Row | Strip | Sole | Cropping Mean |
| CB27 | 12 | 17 | 18 | 16 | 10 | 15 | 17 | 14 |
| M008 | 13 | 33 | 33 | **27** | 11 | 28 | 30 | 23 |
| M043 | 22 | 28 | 24 | 25 | 17 | 23 | 25 | 22 |
| M048 | 12 | 34 | 24 | 23 | 12 | 31 | 27 | 23 |
| M055 | 12 | 32 | 26 | 23 | 12 | 29 | 28 | 23 |
| M076 | 10 | 15 | 17 | 14 | 10 | 16 | 19 | 15 |
| M118 | 13 | 14 | 14 | 14 | 11 | 18 | 18 | 15 |
| M154 | 11 | 23 | 21 | 18 | 10 | 20 | 21 | 17 |
| M176 | 11 | 24 | 20 | 18 | 10 | 20 | 21 | 17 |
| SARC 1-57-2 | 34 | 30 | 22 | 24 | 30 | 26 | 22 | 26 |
| Genotype Mean | 15 | 25 | 22 | | 13 | 23 | 23 | |

2018, LSD (0.05) Intercrop = 2, Genotype = 2, Interaction (G * I) = 3%, CV (%) = 10%
2019, LSD (0.05) Genotype = 2, Intercrop = 1, Interaction (G * I) = 4%, CV (%) = 11%

Table 6. Effect of cropping system and cowpea genotype on the number of seeds per pod of cowpea in 2018 and 2019 cropping season.

| | Seeds per pod | |
|---|---|---|
| **Genotype** | **2018** | **2019** |
| CB27 | 12 | 11 |
| M008 | 9 | 8 |
| M043 | 11 | 10 |
| M048 | 12 | 11 |
| M055 | 12 | 11 |
| M076 | 12 | 11 |
| M118 | 11 | 10 |
| M154 | 13 | 12. |
| M176 | 12 | 12 |
| SARC 1-57-2 | 11 | 11 |
| LSD (0.05) | 1 | 1.10 |
| **Intercrop pattern** | **Seeds per pod** | |
| Row | 10 | 9 |
| Strip | 12 | 12 |
| Sole | 12 | 11 |
| LSD (0.05) | 1 | 0.7 |

2019 was one seed less than that of 2018 in most of the genotype. M008 consistently produced fewer seeds in both years. Strip and sole cropping produced similar number of seeds per pod in both years which were significantly higher than the row intercropping.

Hundred seed weight, a measure of seed size was assessed for the study. Genotype, cropping pattern and their interactions significantly influenced 100 seed weight of cowpea ($P < 0.001$). Averaging across genotype and cropping pattern, 100 seed weight was similar for 2018 and 2019 cropping season. The 100 seed weight of the genotypes when averaged under the sole cropping was significantly higher than that of the strip and the row intercrop in 2018 (Table 7). Strip cropping also produced larger seeds than row cropping. Similar pattern was observed in 2019 cropping season. SARC 1-57-2 consistently produced denser seeds under all cropping patterns. Averaging across the cropping patterns, SARC 1-57-2 had the highest 100 seed weight while M076 had the lowest 100 seed weight. CB 27 under the sole cropping had the highest 100 seed weight but was not significantly different from that of SARC 1-57-2.

The genotype, cropping patterns and their interactions ($P < 0.001$) had significant effect on the grain yield of cowpea (Table 8). In 2018 four genotypes (M008,

**Table 7.** Effect of cropping system and cowpea genotype on 100 seed weight (g) of cowpea in 2018 and 2019 cropping seasons.

| Genotype | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| | Row | Strip | Sole | Cropping Mean | Row | Strip | Sole | Cropping Mean |
| CB27 | 14.60 | 14.07 | 19.00 | 15.89 | 14.30 | 15.70 | 18.70 | 16.23 |
| M008 | 11.33 | 11.50 | 12.73 | 11.86 | 11.07 | 11.20 | 12.43 | 11.57 |
| M043 | 11.63 | 13.40 | 15.17 | 13.40 | 11.33 | 13.10 | 14.87 | 13.10 |
| M048 | 11.53 | 12.07 | 12.63 | 12.08 | 11.23 | 11.77 | 12.33 | 11.78 |
| M055 | 14.17 | 14.77 | 13.33 | 14.09 | 13.87 | 14.47 | 13.03 | 13.79 |
| M076 | 10.80 | 11.70 | 11.23 | 11.24 | 10.50 | 11.40 | 10.93 | 10.94 |
| M118 | 12.20 | 11.43 | 13.33 | 12.32 | 11.90 | 11.13 | 13.03 | 12.02 |
| M154 | 11.63 | 11.90 | 12.33 | 11.96 | 11.33 | 11.60 | 12.03 | 11.66 |
| M176 | 11.93 | 12.07 | 13.37 | 12.46 | 11.63 | 11.77 | 13.07 | 12.16 |
| SARC 1-57-2 | 15.97 | 18.00 | 18.27 | 16.86 | 15.67 | 17.70 | 17.67 | 17.11 |
| Genotype Mean | 12.58 | 13.28 | 14.14 | 13.33 | 12.28 | 12.99 | 13.80 | 13.04 |

2018, LSD (0.05) Intercrop = 0.41 Genotype = 0.82, Interaction = 1.38%, CV = 6.5%
2019, LSD (0.05) Genotype = 0.83, Intercrop = 0.41, Interaction = 1.39%, CV (%) = 6.7%

**Table 8.** Effect of cropping system and cowpea genotype on grain yield of in 2018 and 2019 cropping season (kg/ha).

| Genotype | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| | Row | Strip | Sole | Cropping Mean | Row | Strip | sole | Cropping Mean |
| CB27 | 338.8 | 801.3 | 1638.2 | 926.1 | 323.7 | 772.3 | 1550.7 | 882.3 |
| M008 | 271.1 | 1022.8 | 2015.7 | 1103.2 | 252.9 | 958.6 | 1886.1 | 1032.5 |
| M043 | 353.1 | 874.5 | 1503.1 | 910.2 | 344.9 | 850.6 | 1306.3 | 834.0 |
| M048 | 293.4 | 1437.3 | 2501.3 | 1410.7 | 278.9 | 1358.5 | 2360.5 | 1332.6 |
| M055 | 365.3 | 1426.7 | 2610.1 | 1467.4 | 356 | 1333.3 | 2458.8 | 1382.7 |
| M076 | 267.7 | 786.1 | 1644.6 | 899.5 | 252.3 | 755.2 | 1510.5 | 839.4 |
| M118 | 308.4 | 675.2 | 1359.6 | 781.1 | 287.6 | 678.2 | 1258.7 | 741.5 |
| M154 | 262.4 | 1072.1 | 2047.4 | 1127.3 | 245 | 1034.8 | 1973.9 | 1084.6 |
| M176 | 287.6 | 846.5 | 1528.7 | 887.6 | 259.7 | 802.2 | 1457 | 839.6 |
| SARC 1-57-2 | 564.2 | 1041.9 | 1343.7 | 983.3 | 538.8 | 991.8 | 1255.5 | 928.7 |

**Continued**

| | | | | | | |
|---|---|---|---|---|---|---|
| Genotype Mean | 331.2 | 998.4 | 1819.2 | 314.0 | 953.6 | 1701.8 |

2018, LSD (0.05) Genotype = 20.56, Intercrop = 20.56, Interaction (G * I) = 74.27% CV (%) = 4.0%.
2019, LSD (0.05) Genotype = 43.97, Intercrop = 55.97, Interaction (G * I) = 83.45% CV (%) = 4.7%

M048, M055 and M154) each produced grains that reached one tonne with M048, M055 producing about 1.4 tons. Genotype M118 produced the lowest grain yield which was about 47% less than that of the elite genotype, M055. In 2019 cropping season, the observation made in 2018 repeated itself however, with relatively lower yield values (**Table 8**). The mean percentage decrease in grain yields for row and strip intercropping relative to sole cropping was 18.2 and 54.9 respectively for 2018 cropping season and 18.5 and 56.0 respectively for 2019 cropping season. SARC 1-57-2 consistently in the two years produced the highest grain yield under row intercropping which was about half of a tonne. Averaging the mean obtained from the cowpea varieties and the cropping pattern for the two cropping season, it was observed that the grain yields obtained in 2018 were higher than those in 2019 cropping season.

The genotype, cropping patterns and their interactions all had significant effect ($P < 0.001$) on plant biomass of cowpea (**Table 9**). Averaging the data recorded from the cowpea varieties and the cropping pattern, biomass yield was higher in 2018 than in 2019 cropping season. In 2018, the mean percentage yield of intercropping to sole cropping was 30.1% and 54.7% for row and strip cropping respectively. In 2019, the percentage of row cropping and strip cropping was 30.0% and 55.0% respectively. A trend was observed in all the genotypes where biomass yield reduced from sole cropping to strip intercrop and to row intercrop.

**Influence of maize and cowpea cropping patterns on yield of maize**

Cropping pattern significantly influenced grain yield of maize ($P < 0.001$) in both cropping seasons. There were significant differences between grain yield of maize under the various cropping pattern ($P < 0.001$) for both years. Maize planted under sole cropping recorded higher grain yield than in row and strip cropping pattern (**Table 10**). However, there were no significant differences between the yield obtained under the sole cropping and the row cropping patterns, the lowest yield was obtained under strip cropping pattern. Yield obtained in 2018 was higher than that of 2019. Plant height on the other side was not affected significantly by genotype, cropping patterns and their interactions. Though no significant difference was observed maize height in row intercrop were relatively taller than their respective height in strip and sole cropping.

**Intercrop productivity**

The Land Equivalent Ratio (LER) of the various cowpea genotype intercrop with maize in strip and row intercrop was similar in both cropping seasons (**Table 11**).

**Table 9.** Effect of cropping system and cowpea genotype on biomass (kg/ha) of cowpea in 2018 and 2019 cropping season.

| Genotype | 2018 | | | | 2019 | | | |
|---|---|---|---|---|---|---|---|---|
| | Row (a) | Strip (a) | sole | Cropping Mean | Row (a) | Strip (a) | Sole | Cropping Mean |
| CB27 | 1384 (30.1) | 2425 (52.7) | 4604 | 2804 | 1268 (29.5) | 2191 (51.0) | 4296 | 2585 |
| M008 | 2055 (31.2) | 3741 (56.8) | 6585 | 4127 | 1903 (32.1) | 3333 (56.3) | 5923 | 3720 |
| M043 | 1624 (30.8) | 2697 (51.2) | 5267 | 3198 | 1457 (30.8) | 2544 (53.8) | 4730 | 2910 |
| M048 | 2204 (30.3) | 3815 (52.5) | 7263 | 4428 | 2029 (29.8) | 3168(64.6) | 6804 | 4000. |
| M055 | 2586 (33.1) | 3941 (50.5) | 7808 | 4778 | 2284 (32.0) | 3581 (50.2) | 7140 | 4335 |
| M076 | 2395 (30.8) | 3787 (48.7) | 7771 | 4651 | 2204 (31.0) | 3518 (49.5) | 7106. | 4276 |
| M118 | 1171 (29.6) | 2183 (55.2) | 3957 | 2437 | 1065 (30.6) | 1978 (56.8) | 3480 | 2174 |
| M154 | 1481 (23.2) | 3462 (54.3) | 6372 | 3772 | 1322 (23.0) | 3304 (57.4) | 5760 | 3462 |
| M176 | 1271 (19.7) | 3845 (59.5) | 6467 | 3861 | 1117 (19.3) | 3536 (61.0) | 5798 | 3484. |
| SARC 1-57-2 | 2338 (42.6) | 3774 (68.8) | 5484 | 3866 | 2144 (44.1) | 3594(74.0) | 4859 | 3533 |
| Genotype Mean | 1851 (30.1) | 3367 (54.7) | 6158 | | 1679 (30.0) | 3075 (55.0) | 5590 | |

2018, LSD (0.05) Intercrop = 96.9, Genotype = 103.5, Interaction = 183.9% CV = 3.3%
2019, LSD (0.05) Genotype = 173.0, Intercrop = 190.6, Interaction (G * I) = 316.8%, CV (%) = 5.3%

Variation a (percentage yield relative to sole cropping).

**Table 10.** Plant height and yield of Maize in different cropping patterns in 2018 and 2019 cropping seasons.

| | Height (cm) | | Yield Kg/ha | |
|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 |
| Row | 174.35 | 163.50 | 4409.22 | 4139.30 |
| Strip | 160.23 | 156.36 | 2176.88 | 1910.20 |
| Sole | 156.05 | 159.84 | 4448.00 | 4146.00 |

However, Land Equivalent Ratio in strip intercrop was significantly higher than that of row intercrop in the two growing seasons. Cowpea genotypes M048, M055 and SARC 1-57-2 recorded the highest LER. The productivity of maize was positively affected by the two intercrop pattern (Row and Strip). The results of the benefit cost ratio (BCR) showed that benefit cost ratio for row and strip cropping pattern were greater than 1 for most of the cowpea genotypes intercropped with maize. BCR was higher in 2018 than in 2019. BCR of the row was lower than that of the strip and sole cropping. Three MAGIC genotypes (M076, M118 and M154), did not break even under row intercropping, also under strip intercrop CB27, M076 and M118 did not break even (**Table 12**). M048 and M055 under strip cropping in both seasons recorded higher BCR. The BCR values of four elite genotypes (M008, M048, M055 and M154) grown under sole cropping were higher than that of sole maize in both years (**Table 12**). Under row and strip cropping, SARC1-57-2 recorded the best BCR in both years which were higher than sole cropping. All cowpea genotypes under sole cropping break even and recorded profit.

**Table 11.** Land equivalent ratio of cowpea genotypes intercropped with maize.

| Genotype | 2018 | | 2019 | |
|---|---|---|---|---|
| | Row | Strip | Row | Strip |
| CB27 + maize | 1.19 | 1.40 | 1.20 | 1.41 |
| M008 + maize | 1.19 | 1.52 | 1.16 | 1.39 |
| M043 + maize | 1.14 | 1.34 | 1.21 | 1.53 |
| M048 + maize | 1.18 | 1.82 | 1.12 | 1.50 |
| M055 + maize | 1.23 | 1.69 | 1.18 | 1.47 |
| M076 + maize | 1.15 | 1.37 | 1.14 | 1.35 |
| M118 + maize | 1.13 | 1.30 | 1.15 | 1.43 |
| M154 + maize | 1.10 | 1.39 | 1.10 | 1.43 |
| M176 + maize | 1.21 | 1.45 | 1.21 | 1.45 |
| SARC1-57-2 + maize | 1.35 | 1.47 | 1.48 | 1.68 |
| P values | <0.001 | | <0.001 | |

**Table 12.** Benefit cost ratio of the cropping patterns.

| Genotype | 2018 | | | 2019 | | |
|---|---|---|---|---|---|---|
| | Row | Strip | Sole | Row | Strip | Sole |
| CB27 | 1.08 | 1.14 | 1.54 | 1.04 | 0.98 | 1.43 |
| M008 | 1.07 | 1.38 | 2.07 | 1.02 | 1.19 | 1.91 |
| M043 | 1.05 | 1.20 | 1.35 | 1.01 | 1.05 | 1.08 |
| M048 | 1.06 | 1.91 | 2.71 | 1.01 | 1.70 | 2.55 |
| M055 | 1.17 | 1.89 | 2.85 | 1.14 | 1.67 | 2.68 |
| M076 | 0.99 | 1.07 | 1.55 | 0.94 | 0.91 | 1.37 |
| M118 | 0.95 | 0.97 | 1.14 | 0.89 | 0.85 | 1.01 |
| M154 | 0.99 | 1.47 | 2.11 | 0.94 | 1.30 | 2.03 |
| M176 | 1.09 | 1.18 | 1.39 | 1.04 | 1.01 | 1.30 |
| SARC 1-57-2 | 1.38 | 1.40 | 1.12 | 1.34 | 1.22 | 1.00 |
| Maize | | | 2.04 | | | 1.85 |

## 4. Discussion

**Growths of component crops in cowpea-maize intercrop**

Time of flowering is particularly of great importance in annual crops, including cowpea, as it is a component of the adaptation of a variety to a particular agro-ecological zone and it also determines pod set, crop yield and maturity period [8]. This study revealed that cowpea in sole cropping had earlier days to 50% flowering than cowpea in intercrop. Flowering also differed for the various cowpea genotypes used. The variations observed among the genotypes in days to 50% flowering are due to difference in their genetic makeup. Cowpea genotypes have different genetic makeup and have different physiological responds to flowering. This corroborates with a report by [9] on yield parameter responses in a spreading (cv.M-13) and semi-spreading (cv.Girnar-2) types of groundnut to six growth regulators. The differences observed in the groundnut genotypes growth patterns were attributed to differences in their genetic makeup. Though no significant difference was observed, the sole cropping plots generally recorded earliness to flowering while row intercropping that was shaded more by the maize was late in flowering and the difference could be attributed to competition for resources which include light, In a similar study in sorghum and green gram intercropping system [10] reported that though the difference was not significant statistically, sole cropped green gram took the least days to flower (45 days after emergence), while those intercropped took 51 days to flower. In maize-soybean intercropping study by [11], earliness to flowering was not influenced by cropping system but was influenced by genotypes of the soybean. The arrangement of the cropping pattern in this study ensured that shading of the cowpea in the row cropping pattern was higher than that of strip and the strip also experienced intense shading more than the sole cropping. Plant height of cowpea increased steadily from sole cropping plot to strip intercrop and to row intercrop. The cowpea plants responded to shading by growing taller in order to intercept light. Plant growing in low light condition responds to light stress by devoting more of their available carbon to shoot growth resulting partly in taller stems in search of more light [12]. Growing higher to intercept light explains the difference observed among the cropping patterns. The differences in height of cowpea in the various intercropping patterns could be attributed to shading effect. In row intercrop there was a complete shade over cowpea making them to grow taller in search for sunlight. Genotype with genetic makeup that allows it to tolerate shade will perform well and SARC1 57-2 appears to have that genetic makeup. Plant height of SARC1-57-2 was the tallest in row intercropping and helped it to compete for light with the maize plant than their respective height in sole cropping and strip intercrop, this had effect on the number of pod produced in row intercrop and eventually leading to the highest yield in row intercropping. There are evidences to show that legumes in intercropping system tend to grow taller to obtain sunlight [1] [13] [14].

**Yields of component crops in cowpea-maize intercrop**

Pod per plant is one of the determinant factors of yield in cowpea. Number of pods was higher at strip and sole cropping pattern and lowest at row intercropping and it may be attributed to shading effect of the maize. Shading effect from the maize might have caused lesser pod per plant in row intercrop since genotypes under row intercrop were under denser shade when compared with strip and sole cropping. SARC 1-57-2 performed well under the shade because of its ability to climb the maize plant to intercept sunlight needed for photosynthesis. This culminated in production of more pod than the other genotypes. It has been reported by [14] that in maize-cowpea intercropping system cowpea suffers reduction in the number of pods per plant compared to sole cropping due to competition for resources which include light. In a system where cowpea was intercropped with maize, shading had significant effects on cowpea yield and yield components because it was the shorter variety, and could not compete effectively for resources [15].

Though no significant difference was observed in genotype x intercropping pattern interaction, significant difference was seen in the genotypes in the number of seeds they produced per pod. This observation could be attributed to the difference in the genetic make-up of the genotypes which made some superior over others in terms of seeds per pod. The inherent varietal difference in seed number per pod has been reported in pigeon pea [16]. In the intercrop pattern there was significant difference in seed per pod, row intercropping recorded relatively lower number of seeds per pod than the respective counterpart in strip and sole cropping which may be due to high level of competition, cowpea and maize compete for resources such as nutrients, water and light in row intercrop. This is in conformity with maize/fenugreek intercropping study by [1] that reported that the sole fenugreek produced higher number of seeds per pod compared to the intercropped fenugreek due to competition effect.

The study also showed that the highest 100 seed weight was produced by a collection from SARI, and genotype CB27. The top genotypes from the MAGIC collections were M055 and M043. The genotype with the least 100 seed weight was M076. Differences in 100 seed weight recorded in SARC1-57-2 and MAGIC 076 reflected in their respective grain yields, lower yield was recorded for MAGIC 076 while SARC1-57-2 had higher yield. This could be attributed to their genetic makeup and corroborates with [17] who reported that genetic constitution of some soybeans gives them a slight edge over others and this resulted in the differential seed weight recorded by genotypes. The differences in 100 seed weight could be attributed to genetic differences and the environment created by the cropping pattern. In the intercropping pattern, 100 seed weight were significantly higher in the sole cropping plot than in the intercrops. Within the intercrop, the row intercrop where cowpea competed with maize and light interception was reduced by maize recorded the least 100 seed weight. This may be due to decrease assimilates moving into seeds in intercrop caused by competition for light and nutrients. Similarly, [18] and [19] reported that there is decrease in hundred seed weight of legume in legume-maize intercropping as compared to that of sole cropping perhaps due to competition exerted by maize plants.

Grain yields of cowpea in maize-cowpea intercrop varied in the different cropping pattern. The results showed that all the genotypes had their highest yield in sole cropping pattern. Comparing row and strip cropping patterns, it was observed that the shade tolerant genotype SARC1-57-2 was the highest yielding genotype under row intercropping. Under strip cropping there were only three genotypes (M048, M055 and M154 that recorded higher yield than SARC1-57-2. These morphological features that make SARC 1-57-2 superior in shade may be attributed to its ability to climb the maize plant to access sunlight in the row intercrop. The rest of the genotypes were not able to climb the maize plant to trap enough sunlight for photosynthesis leading to lower number of pod production in row intercrop. As has previously been reported by [20] on maize cowpea intercrop, different cultivars respond differently to intercropping conditions. Averagely higher yield was obtained in sole cropping and strip intercropping with relatively lower yields recorded in row cropping pattern and this could be attributed to availability of sunlight, less competition for nutrients leading to greater number of seeds per pod and increase in pod production. This corroborates with earlier findings by [15] on intercropping of maize (*Zea mays* L.) with cowpea (*Vigna sinensis*) and mung bean (*Vigna radiate*). He reported that in a system where cowpea was intercropped with maize, shading had significant effects on cowpea grain yield and yield components because of cowpea's short stature, and its inability to compete effectively for resources. Similar findings were reported by [21] and [22] who showed that at low planting densities, where there was no interplant competition, yield was higher than in high plant density. Reduction in the yield components and yield from 2018 to 2019 may be due to reduce fertility of the land and environmental stress such as drought in the second year.

**Economic of intercropping early maturing cowpea with maize**

LER values were greater than one in all intercrop patterns, which indicates a yield advantage of intercropping over monocropping of cowpea. The least LER in this study giving a yield advantage of 10% demonstrates the importance of intercropping. Higher LER in intercropping than monocropping has been reported in maize-legume [23] [24]. [25] reported that in maize-soybean intercrop LER was greater than 1. Similarly, Eskandari, (2012) submitted that in maize-mungbean the intercrop showed higher LER than in monocropping.

Benefit-cost ratio, an indicator of relative performance in income and expenditure of a treatment was measured. A treatment is said to be economically viable when the benefit cost ratio (BCR) is greater than 1 [5]. Data from this study show that most genotype under row and strip intercrop pattern gave benefit-cost ratios greater than 1. Three MAGIC genotypes (M076, M118 and M154) did not break even under row intercropping and one (M118) under strip intercrop. The margin needed by the genotypes to break-even was 1% - 5%. This means that intercropping cowpea with maize yielded significant return on investment in most of the genotypes. Some cowpea genotypes (M008, M048, M055, M154) and the maize under sole cropping posted a BCR that was above 2. These same genotypes were the top five in grain yield under sole cropping. Under the intercropping, the strip gave better BCR than row and M048, M155 and SARC1-57-2 were the top three genotypes for all the cropping pattern. These three were among the top five in grain yield. When farmers want to maintain the row intercropping then SARC1-57-2 and M055 which break even with 38% and 17% profit and were among the top five in grain yield could be recommended to them.

## 5. Conclusion

Based on the study, significant differences in plant height and grain yield were observed among the genotypes of cowpea. SARC1-57-2 was superior to the other genotypes in terms of shade tolerance and also recorded the tallest height. MAGIC genotypes, M048, M055, M076 M176 and SARI collection SARC1-57-2 were the top five genotypes in fodder production and grain yield in intercropping system. Therefore, M048, M055, M076 M176 and SARC1-57-2 can be recommended to farmers for intercropping.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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