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Physiological Efficiency of Corn-legumes Intercropping Systems under Conservation Agriculture Practice Systems (CAPS) in Northern Mindanao, Philippines

Apolinario B. Gonzaga, Jr.
College of Agriculture
University of Science and Technology of Southern Philippines – Claveria
Claveria, 9004 Philippines
apolgonzaga78@yahoo.com

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Abstract

Conservation Agriculture Practice Systems (CAPS) is a recent agronomic innovation that is tailor-fitted approach for successful adoption of conservation agriculture (CA). In this study, the influence of various CAPS in a corn-legumes systems on key physiological parameters of corn such as leaf area index (LAI), net assimilation ratio (NAR), dry matter yield (DMY), harvest index (HI) and grain yield (GY) were evaluated at various crop stages (30, 60, 85 days after planting and at harvest) , in two cropping seasons, respectively. Five corn-based cropping systems (CS), namely: CS1 (corn + Arachis pintoi – Corn + A. pintoi), CS2 (corn + Stylosanthes guianensis – Corn + S. guianensis), CS3 (corn + cowpea – upland rice + cowpea), CS4 (corn + rice bean – Corn + Rice bean) and CS5 (corn – corn), were employed as treatments. LAI, DMY, HI and GY were significantly influenced by the various imposed CAPS relative to the control (CS5, sole corn). However, recorded NAR values showed to be higher in CS5 (sole corn). Highest GY was obtained in CS2 (4.26 t ha^{-1}) as the mean for the 2-cropping seasons. Among the CAPS, the used of A. pintoi and rice bean proved to be a promising associated legumes species to complement the base crop. Results of the study, provides the initial merits of adoption of CAPS in Northern Mindanao within the context of productivity, profitability and resiliency amidst a changing climate.

***Keywords**:* CAPS, corn-legumes, physiological parameters, agronomic innovation, Northern Mindanao

1. Introduction

Conservation Agriculture (CA) refers to the system of raising crops with minimal disturbance to the soil while retaining crop residues on the soil surface. It is perceived to be one of the many practices that can sustain agricultural productivity (Derpsch 2008; Kassam *et al.*, 2012) and reduce soil erosion effectively (Lal *et al.*, 2007; Balde *et al.*, 2011). The Food and Agriculture Organization (FAO, 2011) characterized CA as a system that maintains a permanent or semi-permanent organic soil cover which can be a growing crop or dead mulch. Its function is to protect the soil physically from sun, rain, wind and to feed soil biota. It is a recent agricultural management system that is gaining popularity in many parts of the world (Hobbs *et al.*, 2008). Recent results of Kumar and Babalad, 2018 showed that adoption of CA increased the soil organic carbon sequestration potential, microbial biomass and enzymatic activities over a period of two years.

Furthermore, CA aims to conserve, improve and make more efficient use of natural resources through integrated management of available soil, water and biological resources combined with external inputs. Hence, it contributes to environmental conservation, as well as to enhanced and sustained agricultural production or a system approach to sustainable agriculture (Li *et al.*, 2011). It spearheads an alternative no-till agro-ecological paradigm that is making an increasing contribution to sustainable production intensification (Kassam *et al.*, 2009).

The concept of CA which involves minimal soil disturbance, continuous retention of residue, mulching of soil surface, and diverse and rational use of crop rotations (Erenstein *et al.*, 2008; SANREM, 2009), constitute the basis of CAPS. It is a tailor-fitted approach for successful adoption and implementation of CA to specific location. It involves optimum integration of seed or seedling establishment methods, farm implement selection, choice of crops in rotation, germplasm suitability, mulch and fodder management, demand for produce, profitability, nutrient management, farmer preferences and skills, local government policies, credit availability, production inputs, labor, gender, and other various concerns (SANREM, 2009). In Asia at present, there are still few adopters of CAPS despite gaining ground as an emerging alternative to conventional tillage-based agriculture worldwide. According to Ella *et al.*, (2012), Cambodia, Vietnam, China and recently the Philippines are the only few Asian countries wherein research on CAPS are being conducted for future adaption.

In sloping uplands lands, cropping patterns are monocropping or multiple cropping of cereals (e.g. corn and rice), root crops (cassava and sweet potato) and vegetables (e.g. tomato, sweet pepper, cabbage, etc.) or combinations of these crops. Corn is one of the most important crop cultivated both for food and feed, thus a good test crop in assessing the local impact of CAPS. In

Northern Mindanao, corn is the most extensively cultivated cereal serving as most important annual cash crop for upland farmers in the region. Similarly, the challenge for CAPS to be adopted by local farmers is to test its adaptability and efficiency under the local farming landscapes. This gives a scientific basis of the adoption of CAPS as a tailor-fitted approach agronomic innovation using corn as the most widely cultivated cereal in the region.

Meanwhile, measurement and determination of physiological parameters have been extensively used to improve the management of certain species or to explain differences among cultivars (Restrepo-Díaz *et al.*, 2010). Functionally, it serves as the basic evidences in the interpretation of the various crop performances under various agroecosystems and cultural management.

Hence, this study in general aimed to determine the physiological efficiency of corn in a corn-legumes intercropping systems under various CAPS in a sloping upland agroecosystem. The specific objectives were (1) to evaluate and determine key physiological parameters in corn-based cropping system in different (CAPS); (2) to determine the grain yield and grain yield components of various corn-based cropping systems imposed under CAPS; and (3) to identify the most suitable conservation agriculture practice that will optimize corn yield in an upland sloping ecosystem.

2. Methodology

2.1 Time and Place of the Study

The experiment was conducted from November 2011 to November 2012 at Bug-ong, Rizal, Claveria (North 8.65655^0, East 124.86229^0) in Misamis Oriental, Northern Mindanao. Experimental trials covered the typical two corn cropping per year in the study site.

2.2 Description of the Experimental Site

Study site is located in a sloping upland agroforestry farm currently use as research site for the World Agroforestry Center (formerly ICRAF). The slope is 26% based on clinometers measurement, and used to be a former ranching area. Typical native vegetation growing in the landscape prior to the implementation of the research project includes cogon (*Imperata cylindrica*), tigbaw (*Saccharum spontanium*), dinog (*Antidesma ghaesembilla* Gaertn) and other grasses and shrubs. The area is a typical upland farm of the country and in most tropical areas in Southeast Asia.

The topography as described by Mercado (2007), ranges from undulating land forms to incised plateau, with elevation of 350-950 meters above sea level (masl). Approximately, 62% of the total land area is rolling to very steep. Soil materials are classified as acid upland soils with fine mixed isohyperthermic, Ultic Haplorthox as the general taxonomic classification (Mercado, 2007). The major soil series dominating the landscape is Jasaan Series with Jasaan clay loam, and Jasaan clay as major soil types. Jasaan Series is classified under Order Oxisol. Other Orders found in the area are Inceptisols and Alfisols (PCAARRD, 1998). However, in this study it appears that the soil material in the experimental site possessed more of a characteristics of an Ultisol as evidenced by high cation exchange capacity (CEC) (> 21 me/100g) as against the typical lower CEC values of an Oxisol (<16 milliequvalent/100 gram, me/g).

Soil erosion rate is 200-350 mg ha^{-1} yr^{-1} (Fujisaka *et al.*, 1995; Mercado, 2007). Average annual precipitation is 3000 mm that is distributed throughout the year that normally peak during the months of June and October.

2.3 Experimental Design Treatments

The experiment was laid out in randomized complete block design with four replications with the different CAPS plus the conventional method cropping systems (CS1 – CS5) were used as treatments. Individual plot with a measurement of 10 meter x 10 meter, with 2 meter space between treatments within a replication and 3 m between replications were laid out and used as plot size. Different corn-legumes cropping combinations imposed as treatments are given below:

CS1 = Corn + *A. pintoi* – Corn + *A. pintoi*
CS2 = Corn + *S. guianensis* – Corn + *S. guianensis*
CS3 = Corn + Cowpea – Upland rice + Cowpea
CS4 = Corn + Rice bean – Corn + Rice bean
CS5 = Corn – Corn

Based on the operating pillars of CAPS, namely: i) minimal soil disturbance, ii) continuous mulching, and, iii) diversified crop rotations, different cropping systems were imposed as treatment variables.

2.4 Varieties and Species Used

Hybrid corn (NK Super Jumbo, Syngenta Inc.) was planted in all treatments in both seasons. Local varieties of cowpea, rice bean and local sources of *A. pintoi* and *S. guianensis* were used as associated legumes or living mulches.

2.5 Nutrient Management

Fertilizer recommendation applied in all cropping system treatments was 120-60-60 (N-P_2O_5-K_2O) in both growing seasons. Lime ($CaCO_3$) was applied during the first cropping season applied at a rate of 3 t ha^{-1}. Phosphorus (P) and potassium (K) in the form of ammonium phosphate (16-20-0) and muriate of potash (0-0-60), respectively, were applied as basal during planting. Nitrogen (N) source, urea (46-0-0) was applied at 16-21 and 30-31 days after planting (DAP).

2.6 Harvesting

Corn was harvested on all cropping systems for both cropping seasons at 110 DAP. This is in accordance with the typical and observed maturity period for corn in the study area. Cowpea and rice bean were harvested when pods were mature, and final harvesting was done at the end of the cropping season. Living mulches were also harvested at the end of the cropping season.

2.7 Data Gathered

2.7.1 Physiological Parameters

Destructive samplings were done at different crop stages (30, 60 and 85 DAP) to determine key physiological parameters. Determination of LAI, NAR, DMY, HI and grain yield and yield component were done using four sample plants per treatment per sampling time, respectively.

LAI refers to the ratio of the leaf surface to the ground area occupied by the crop (Gardner *et al.*, 1985) which can be a major determinant of light interception and transpiration.

The LAIs at 30, 60 and 85 DAP were calculated using the formula:

$$LAI = \frac{LA}{GA} \qquad (1)$$

where:

LAI = Leaf area index
LA = Leaf area
GA = Ground area

Four representative corn plants per sampling period were selected starting from third row from the outer border per plot/treatment were subjected to destructive sampling at 30, 60 and 85 DAP, respectively. All functional leaves were measured (length and the widest part), and leaf area was calculated as leaf length times maximum width times *K*, where *K* is a shape factor with values 0.75. Subsequently, *LAI* was calculated using the abovementioned formula.

NAR is the dry matter accumulation or increased in plant dry weight per unit leaf area per unit time, and it is expressed in grams m^{-2} of leaf area per day ($g\ m^{-2}\ d^{-1}$). Net assimilation rates 30-60 and 60-85 DAP were calculated using the formula:

$$NAR = \frac{(W_2 - W_1)\,(In\ LA_2 - In\ LA_1)}{(LA_2 - LA_1)(T_2 - T_1)} \qquad (2)$$

where:

$W_2 - W_1$ = Change in weight
$LA_2 - LA_1$ = Change in leaf area
$T_2 - T_1$ = Change in time

DMY refers to the entire aboveground organic dry matter produced from essential activities of photosynthesis and protein metabolism (Fageria *et al.*, 2006). This includes the dry weight of leaves, stems, ears and the grains measured at 30, 65, 85, and 110 DAP or maturity.

HI reflects the proportion of assimilate distribution between economic and total biomass (Gardner *et al.*, 1985) expressed in dry weight basis. It refers to the efficiency of translocation of assimilates to the desired sink or the coefficient of effectiveness on the movement of dry matter to the grains. The *HI* was measured at harvest and was computed using the formula:

$$HI = \frac{\text{Economic yield (kg)}}{\text{Biological yield (kg)}} \times 100 \qquad (3)$$

GY parameter was measured from 6 x 6 center rows (0.75 m x 0.20 m distance between rows) sampling area located at the center of each plot. Grain yield was adjusted to 14% moisture content (MC), and at per hectare basis using the formula:

$$GY = \frac{\text{Grain weight (kg)}}{1{,}000 \text{ kg ton}^{-1}} \times \frac{10{,}000 \text{ m}^2 \text{ ha}^{-1}}{\text{plot size (m}^2\text{)}} \times \frac{100 - MC}{86} \qquad (4)$$

3. Results and Discussion

3.1 Physiological Characters

3.1.1 Leaf Area Index

Leaf area index is a parameter that reflects the development of the leaves (or leafiness of the crop) which is a critical factor in capturing light interception for canopy photosynthesis. The LAIs of corn at 30, 60 and 85 DAP, planted under different cropping systems and cropping seasons are shown in Figure 1.

During vegetative stage (30 DAP), corn LAI did not vary among cropping system treatments. At 60 DAP, highest LAI in corn was observed in corn intercropped with rice bean (CS4, 2.52). On the other hand, sole corn (CS5) had the lowest LAI (1.31). At the green or young corn stage (85 DAP), significant variations between cropping systems with CAPS (CS1, CS2, CS3, and CS4) and conventional monocrop corn were recorded. Irrespective of the cropping systems, CAPS treatments had higher LAIs values than the conventional corn monocropping. The LAI values in corn + *A. pintoi* (CS1, 2.15) and corn + *S. guianensis* (CS2, 2.12) produced the highest LAI values. Although the LAI values of corn + cowpea (CS3) and corn + rice bean (CS4) LA were relatively lower, these treatments have higher LAI values than the conventional treatment. Report of Balde *et al.*, 2011 showed that systems with maize intercropped with a cover crop had higher LAI than systems with corn grown as sole crop.

Critical LAI of corn is defined as the LAI with 95% solar radiation interception. Several workers indicated that maximum critical LAI for corn is 3-4 (Lindquist *et al.*, 1998).

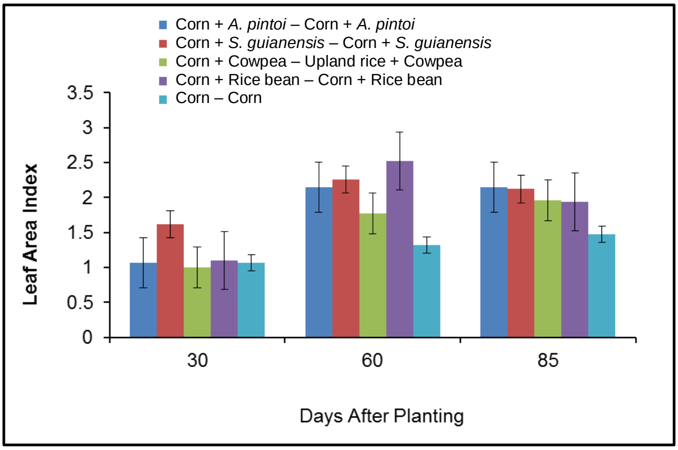

Figure 1. Leaf area index crop at varying crop stages as influenced by different cropping systems

Measured LAI during the first cropping at 30, 60 and 85 DAP were consistently higher compared to second cropping (Figure 2). This can be attributed to a more favorable environmental condition in the area, which is more favorable for corn production. In this study, LAI values were comparably smaller as those reported by Amanullah *et al*. (2007) with measured LAI ranging 2.86-3.27 using similar amount of N fertilizer (120 kg ha^{-1}). Ahmad *et al*. (2010) recorded higher LAI ranging 1.0-6.0. Lindquist *et al*. (1998) reported that LAI values of 3-4 are maximum to attain optimum yield.

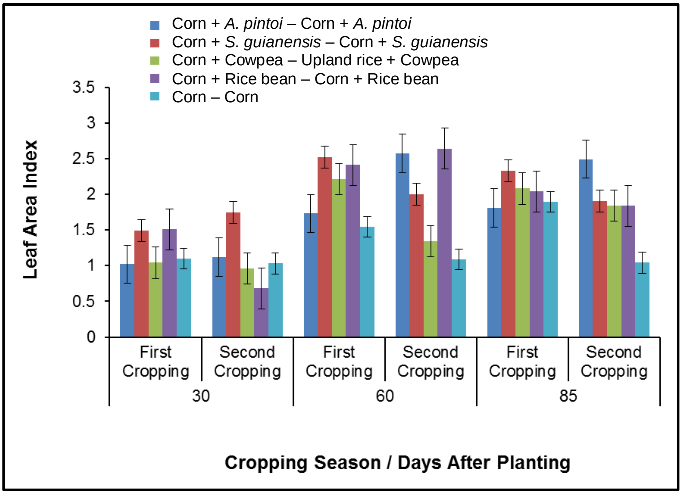

Figure 2. Interaction effect of cropping seasons and cropping systems on the leaf area index of corn at 30, 60 and 85 DAP

3.1.2 Net Assimilation Rate

NAR reflects the efficiency of plant dry matter production. Corn NAR values at 30-60 and 60-85 DAP were influenced by both cropping system and the growing season (Figures 3 and 4).

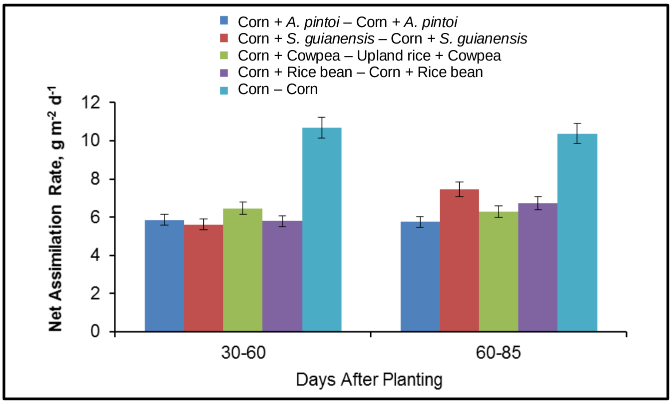

Figure 3. Net assimilation rate of corn in varying cropping systems (Average of two cropping seasons)

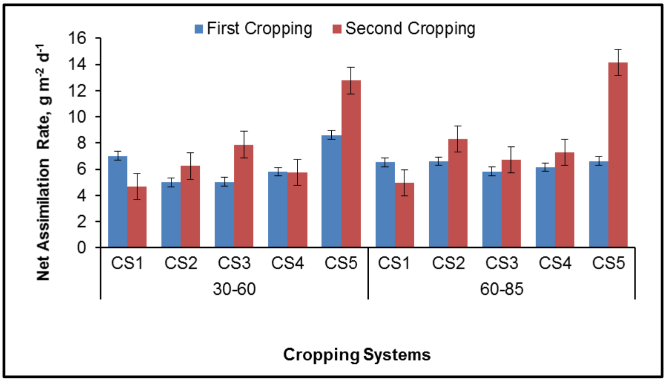

Figure 4. Net assimilation rate of corn at varying crop stages as influenced by cropping systems during two cropping seasons

Within 30-60 DAP, significantly highest NARs were obtained in sole corn cropping system (CS5) in both cropping seasons, with 8.61 g m^{-2} d^{-1} (first cropping) and 12.77 g m^{-2} d^{-1} (second cropping). Within 60-85 DAP, NAR values of sole corn cropping system (CS5) remained to be highest (10.38 g m^{-2} d^{-1}) among cropping systems.

NAR is a measure of the net gain of assimilates, mostly photosynthetic, per unit of leaf area and time and the average photosynthetic efficiency of leaves in a crop community (Gardner and Pearce, 1985). Both cropping systems and seasons have significantly influenced the NAR values of corn at 30-60 and 60-85 DAP.

3.1.3 Corn Dry Matter Yield

DMY is presented in Figure 5. The cropping system treatments have differential effect on corn total dry matter (TDM) production in this study. At 30-60 DAP, among the cropping systems implemented higher corn DMY was obtained in CAPS plots compared with the sole corn conventional treatment.

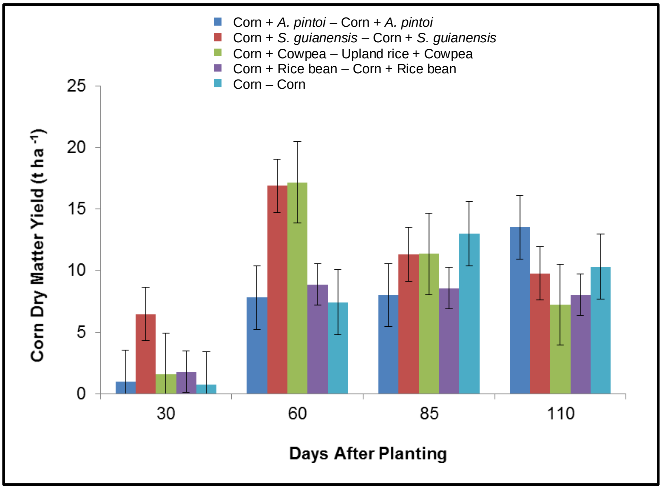

Figure 5. Total dry matter yield of corn in varying cropping systems (average for 2 cropping season

From 85 DAP to maturity (110 DAP), only CS1 (Corn + *A. pintoi* – *A. pintoi*) had out yielded the conventional cropping system (corn-corn). Among conservation agriculture practices treatments, corn+ *A. pintoi* had the highest corn DMY (13.53 t ha^{-1}) among the treatments. On the other hand, CS3 (corn + cowpea) produced the lowest corn DMY at harvest (Table 1).

Table 1. Dry matter yields of corn and other crops under different cropping systems

Treatment	Dry Matter Yield (t ha^{-1})	
	Corn at 110 DAP (Harvest)	Associated Legumes
Cropping Systems	**	**
Corn + *A. pintoi* – Corn + *A. pintoi*	13.52a	3.56 b
Corn + *S. guianensis* – Corn + *S. guianensis*	9.78c	5.45 a
Corn + Cowpea – Upland rice + Cowpea	7.23e	1.08 d
Corn + Rice bean – Corn + Rice bean	8.02d	2.48 c
Corn- Corn (conventional plow based system)	10.32b	3.62 b
Cropping Season	**	**
First Cropping	12.23a	2.65 b
Second Cropping	7.32b	3.82 a
CV	5.24	4.73

In a column, means followed by the same letter are not significantly different at 5% level of significance by LSD.

Significant variations in corn DMY among cropping system treatments was observed at maturity (110 DAP) in both cropping seasons. Although, no significant differences in DMY was noted across seasons, relatively higher DMY (36.7 t ha^{-1}) was obtained during the first cropping compared to the second cropping (32.48 t ha^{-1}), DMY values were computed as a sum of all the cropping systems imposed as treatments per season. i.e. 12% higher DMY difference. This could be attributed to better climatic conditions during the first cropping period. The accumulation of dry matter at maturity in turn, is the integration of light interception and light utilization by the crop canopy throughout the life cycle of corn and sustaining leaf photosynthesis during the grain-filling period appears to be a major contributor to increases in DM accumulation (Tollenaar and Lee, 2006). The DMY to some extent is affected by environment and crop management factors (Moser *et al*., 2005), which was clearly shown in the study.

Generally, a non-linear growth was observed from the early stage of growth to maturity wherein differential growth and development in response to cropping systems as treatments was observed (Figure 5). Dry matter yield started at lower values, then as growth progresses there was also increased in dry weight towards maturity (110 DAP) in most of the cropping systems.

The DMY of corn and associated legumes (Table 1) in 2 cropping seasons indicated that corn intercropped with legumes had the significantly highest

DMY at harvest (110 DAP) specifically in CS1 (corn + *A. pintoi*) with an average of 13.52 t ha^{-1}. This was followed by CS2 (corn + *S. guianensis*, 9.78 t ha^{-1}), while the lowest DMY was CS3 (corn + cowpea, 7.23 t ha^{-1}). Between cropping seasons, significantly higher DMY was attained during the first cropping (12.23 t ha^{-1}) as compared from the second cropping (7.32 t ha^{-1}).

On the other hand, associated legumes produced varying DMYs (functions of species intercropped). Highest DMY was obtained in *S. guianensis* of CS2 (5.45 t ha^{-1}) followed by *A. pintoi* in CS1 (3.56 t ha^{-1}) while cowpea in CS3 produced the lowest DMY (1.08 t ha^{-1}). Legume intercrops have higher DMY during the second cropping season. This trend was in contrast with the obtained yield of corn-corn in which a significantly much higher yield were attained during the first cropping than the subsequent cropping season. This result can be attributed with the adaptability of legumes during the first cropping season.

3.1.4 Harvest Index

HI reflects the efficiency of photosynthates or assimilates partitioning between vegetative parts and economic yield. HI (Figure 6) varied significantly within cropping system treatments imposed regardless of cropping seasons. HI of 0.43 was obtained in CS1 which is significantly higher than the rest (CS2-CS5) of the cropping systems, having values of 0.33-0.37. The mean HI for sole corn (CS5) was 0.33, relatively the lowest among CS treatments, although did not differ statistically with CS3 and CS4.

The consistency of dry matter partitioning at 85 DAP and at harvest was not observed. Cropping system treatments with higher PC to the ears (CS2, CS3 and CS5) at 85 DAP did not translate to higher HI at maturity (110 DAP). An explanation for this observation is that, total dry matter which is essentially the same when PC is summed up can remain essentially the same while the harvest index increased (Gardner and Pierce, 1984). Fageria *et al*., (2006) reported that increased grain yields in small grains were primarily due to increases in the harvest index.

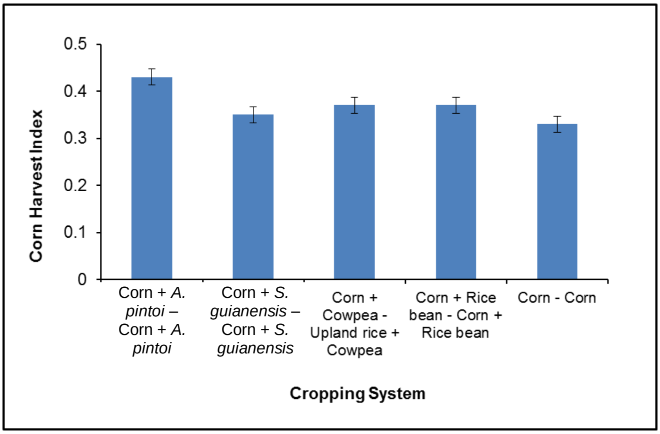

Figure 6. HI of corn under varying cropping systems

The DMY of CS1 (Corn - *A. pintoi*) was the highest among cropping systems, which might have influenced the HI (corn) in this cropping system. Although in terms of absolute DMYs, higher corn HI did not reflect higher yields as in the case of CS1, this indicates possible limitation of translocation efficiency from the vegetative tissues (source) to the sink tissues (ears) at maturity under high DMYs cropping system. Sinclair (1998) reported that HI is an indication of how the vegetative mass (biomass) is allocated to seed at maturity. Furthermore, partitioning of DM to the grain is a function of kernels per plant and weight per kernel (Tollenaar and Lee, 2006). Result in this study shows that DMY is positively associated with HI (Table 2).

Table 2. Correlation coefficient (r) among grain yield (GY), dry matter yield of corn (DMYC), weight of 1000 kernels (KWT), number of kernels per ear (KPER), and harvest index (HI)

	DMYC	KWT	KPER	HI
GY	-0.11ns	0.54**	0.17ns	-0.12ns
DMYC		0.10ns	-0.49**	0.34*
KWT			0.21ns	-0.17ns
KPER				-0.48**

ns = not significant at 5% level; * = significant at 5% level; ** = significant at 5% level

Correlation analyses revealed that grain yield is moderately positively associated with 1000-kernel weight as yield component. It is also negatively correlated with both dry weight and harvest index. While HI appeared to be correlated to dry matter yield but not affected by kernel weight. Positive correlation in dry matter yield relative to harvest index among treatment generally resulted to greater yields of the employed cropping systems as treatments.

Corn harvest index values varied between the two cropping seasons. Generally higher HI was obtained during first cropping (0.39) as compared to the second cropping (0.35). Higher cumulative solar radiation was recorded during the first cropping season (2,402.1 MJ m^{-2}), coupled by sufficient amount of moisture of 1,592.8 mm (Figure 6) that probably influenced the variation of corn HI between seasons. Numerous studies have reported that the interaction effect of inherent crop or varietal characters and agro-climatic conditions can influence corn DMY as well as the partitioning of dry matter to the grains at the later growth stages as reflected in the HI parameter.

3.1.5 Grain Yield and Yield Components

Grain yield differed among cropping system treatments (Table 3). Higher grain yields were obtained in cropping systems under CAPS, corn intercropped or sequenced with legume) compared to the conventional (corn-corn) cropping system. The only difference was noted in CS1 (corn + *A. pintoi*) wherein yield (3.27 t ha^{-1}) was less than the conventional (3.45 t ha^{-1}). Highest yield was obtained in CS4 (corn + rice bean) which is comparable with the recorded grain yields of CS2 (corn + *S. guianensis*) and CS3 (corn + cowpea).

Grain yield computed in a yearly-basis involving 2 cropping seasons indicated a higher yield for CS2 (corn + S. *guianensis*, 4.26 t ha^{-1} followed by CS4 (corn + rice bean) with an average of 4.19 t ha^{-1}. The lowest grain yield was obtained in CS1 (corn + *A. pintoi*, 3.37 t ha^{-1}) followed by the conventional treatment (sole corn, 3.45 t ha^{-1}). These results suggested that different cropping systems with CAPS features can support normal yields in addition to its conservation properties.

Corn yields between seasons did not vary, although relatively higher grain yields were obtained in first cropping season (3.94 t ha^{-1}), 5% higher that of the second cropping (3.71 t ha^{-1}). Grain yield is a function of multiple factors, among of which are dry matter accumulation and harvest index (Tollenaar and Lee, 2006). It is also influenced by key yield components, being the product of the number of kernels per unit ground area and the mean kernel weight. The number of kernels per row and the number of ears per plant determines the corn yield.

Table 3. Grain yield and yield components of corn in different cropping systems

Treatment	Grain Yield (t ha^{-1})	1000 Kernel Weight (g)	Number of Kernels per Ear
Cropping System	*	Ns	*
Corn + *A. pintoi* – Corn + *A. pintoi*	3.27 c	318.63 ab	469.38 b
Corn + *S. guianensis* – Corn + *S. guianensis*	4.26 a	386.13 a	505.00 b
Corn + Cowpea – Upland rice + Cowpea	3.96 ab	308.75 b	507.75 ab
Corn + Rice bean – Corn + Rice bean	4.19 a	336.00 a	546.00 a
Corn- Corn	3.45 bc	323.36 ab	504.38 b
Cropping Season	ns	Ns	ns
First Cropping	3.94 a	327.55	502.15
Second Cropping	3.71	321.6	510.85
CV	17.28	8.08	7.89

*CV= Coefficient of Variation
In a column, means followed by the same letter are not significantly different at 5% level of significance by LSD

Yield improvement in corn is the result of changes in underlying physiological processes and yield improvement can be dissected into physiological component processes at the whole-crop level (Tollenaar and Lee, 2006). In this study, grain yield as a function of kernel weight and number of kernels per ear was more influenced by the latter than the former yield component. However, further analysis revealed that although the number of kernels per ear had influenced the yield due to varying cropping systems, the influence of 1000-kernel weight was also apparent. Thus, higher grain yields can be obtained by heavier weight of kernels coupled with more number of kernels developed in the ear.

Results of Das *et al.*, 2018 revealed that yield of maize and wheat was significantly influenced by the practice of conservation agriculture relative to conventional practices by the farmers spread on a three year period.

In this study, the compensation of the two yield components was apparent. A higher thousand kernel weight (386 g) but lower number of kernels per ear (505) was observed in the highest-yielding cropping system. The second high-yielding cropping system (CS4) has lower thousand kernel weight (336 g) but compensated by greater number of kernels per ear (546).

Total dry matter partitioning was observed to be higher in both CS2 and CS4 compared to the other cropping systems. LAI values were also higher in the above-mentioned cropping systems. Hence, over-all influence of the mentioned parameters resulted to higher yields in CS2 and CS4.

4. Conclusion

Key physiological parameters in corn-legumes intercropping systems under different CAPS imposed as treatments in two cropping period were evaluated. Climatic factors were found to be favorable for corn growth parameters during the first cropping season compared to the subsequent cropping period. This resulted to better LAI, leaf area ratio (LAR) and NAR of corn sampled at 30, 60 and 85 DAP. Measured DMY and HI, however, were not influenced by the cropping season.

Imposed treatments or cropping systems termed as CAPS were found to influence various growth parameters. Increment in LAI, LAR and NAR were observed to be influenced by various cropping systems as treatments. Among cropping systems, CS2 (corn + *S. guianensis*) and CS4 (corn + rice bean) appeared to be significantly influenced by different CAPS. Comparison between CAPS treatments and sole corn showed that various growth parameters were enhanced in CAPS relative to corn monocropping. Moreover, interaction effect between cropping season and systems proved that several CAPS significantly influenced growth and development of the test crop (corn). Consistently CS2, CS3 and CS4 obtained better agronomic and growth parameters as compared to monocropped corn. This translates to higher grain yield for the above-mentioned treatments. Total productivity and dry matter yield of associated legumes were favoured during the first cropping season.

In addition, other legumes species which are known to be well adapted in terms of growth and consumer preferences such as mung bean and soybean should also be considered for inclusion in the location-specific approach of CAPS.

In this study, several opportunities and limitations were met and realized. Better total systems productivity should have realized if other parameters (e.g. land equivalent ratio (LER), sampling size for legumes) have been measured thoroughly. Initial results however will serve as benchmark data on the on-going interest and location-specific approach of CAPS.

However, cropping season did not show any significant effects on most growth related parameters except for LAI, LAR, NAR and HI, respectively.

5. Acknowledgement

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