

## EFFECT OF *CASSIA SPECTABILIS*, COWDUNG AND THEIR COMBINATION ON GROWTH AND GRAIN YIELD OF MAIZE.

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### ABSTRACT

*Cassia spectabilis* prunings and cowdung as soil amendments were used to improve soil chemical properties and increase maize yield. Treatments to supply 1, 2, 3, or 4 t ha<sup>-1</sup> of cowdung alone, 2 t ha<sup>-1</sup> *Cassia spectabilis* alone and 2 t ha<sup>-1</sup> *C. spectabilis* in combination with 1, 2, 3, or 4 t ha<sup>-1</sup> cowdung were applied to a Clayey Kaolinitic Typic Haplustox at Misamfu. A grass mound was used as a control. A randomized complete block design with 4 replications was used. Maize (MMV 400) was the test crop. Soil samples collected at the beginning and end of the study were analyzed for pH, organic C, total available P, exchangeable K, Ca, Mg and Na. Plant height, dry matter, grain yield and nutrient uptake were assessed. Results showed significant increases in plant height (65 %, 59% and 13 %) at 3 growth stages with 99% grain yield increase over the control due to increased N (126.6 %), K, Mg uptake in treatments receiving *Cassia* + cowdung. In these treatments, soil C/N ratios decreased by 5.5% while N and P concentrations increased by 33.3 % and 10.4 % respectively, across all treatments. The study suggests the need for using animal and plant manures together to improve maize nutrition.

**Keywords:** *Cassia spectabilis*, *chitemene*, cowdung, *fundikila*, inorganic fertilizer, organic manure, soil fertility.

### INTRODUCTION

As small-scale farmers intensify crop production, land becomes more prone to soil degradation due to shorter or absence of fallow periods. To use this land continuously, deliberate soil management strategies that improve soil organic matter are required. Incorporating green manure to soil would provide multiple benefits of improving the soil chemical and physical status and in turn improve maize yield. The environment in the High Rainfall Zone (HRZ) of Zambia and the traditional practices of the people provide little support for permanent agriculture. The HRZ consists of highly weathered and strongly leached acidic soils that are low in native fertility (Brammer, 1976). Low pH, high aluminium and manganese concentrations are high on the list of major factors causing soil infertility. In order to overcome the above soil constraints to crop production, especially for maize which is a staple crop, farmers have traditionally practised forms of land husbandry such as *Chitemene* (slash and burn) and *Fundikila* (*Hyparhaenia* grass mound) and the use of cattle manure as coping strategies to replenish soil fertility (Mwakalombe and Mapiki, 1997). However, practices such as *Chitemene* are no longer sustainable due to increased pressure on land due to the rising population. The *Fundikila* practice is also of low productivity due to the poor quality of biomass used in the mounds leading to yield decline after only a few years of cultivation. The continuous use of inorganic fertilizers alone has proven unsustainable in smallholder agriculture. Not only is the material expensive, it is also often unavailable for timely application. Dalland *et al.* (1993) and Stocking (1988) have demonstrated that the continuous application of nitrogenous fertilizers has negative effects on the soil. They showed that as urea application in fertilized maize systems is increased, significant decreases in soil pH, Mg and K concentration and increases in Al concentration are recorded. They warned against the use of chemical fertilizers alone in improving soil fertility.

It has been established that the type and quality of organic resources used have an effect on the decomposition and nutrient release rates. Fast decomposers provide large amounts of nutrients in early stages of crop growth but may not influence soil physical conditions whereas slow decomposers have the opposite effect (Tian *et al.*, 1993). Some green manure plants decompose faster and release nutrients much quicker in the early stages of plant growth thus contributing more to the initial supply of plant nutrients (Ladd *et al.*, 1981). Farmyard manures on the other hand act as slow nutrient release fertilizers. This characteristic is desirable as there is a reduction in the leaching loss of N due to the slow decomposition rate and the slow release of ammonium N and its resulting slow conversion rate to nitrate (Murwira and Kirchman, 1993). Reddy *et al.* (1986) evaluated several tropical legumes as green manure for maize in the United States. The results showed that the yield of maize in green manure plots ranged from 3.4-5.7 t ha<sup>-1</sup> with a mean of 4.2 t ha<sup>-1</sup>, compared with 2.7 t ha<sup>-1</sup> produced on the fallow plot.

Some work on the effect of organic manure on maize yields in Brazil showed that green manuring with legumes in general increased maize yield from 0.7 to 3.7 t ha<sup>-1</sup> over the control (Bowen, 1987; Carsky, 1989). Maize yields of up to 6.3 t ha<sup>-1</sup> were achieved using the legume green manure *Mucuna* as the N source.

The potential of optimizing cowdung use for maize was studied by Munguri *et al.* (1996) in Chinyika area in Zimbabwe. Their findings from on-farm trials on the effect of cattle manure quantity and application method showed little or no effect on maize grain yield. Station placement of manure gave the highest yield and was superior to broadcasting. However, results were similar to those of drilling in the planting furrow. Charreau (1975) found that fertilization with farmyard manure reduces or reverses acidification, increases Ca and Mg, reduces the content of Al and Mn and promotes root growth and uptake of P. Studies on plant-animal waste combinations conducted by Agbim (1981, 1985, 1988) produced positive responses and

significant results on combinations of cassava peels and cattle dung on the yield of intercropped yam and bean.

## MATERIALS AND METHODS

### Location, climate and soils

The trial was conducted at Misamfu Research Centre in Kasama, Zambia. The area is in the high rainfall zone and receives an average of 1,200 mm of rainfall per annum. The approximate location is 10° 1' S and 31° 10' E at an altitude of 1,380 m above sea level. The area has a wet season from November to April and a dry season from May to October. The soil is Misamfu Red Series classified as a Clayey Kaolinitic Isohyperthermic Typic Haplustox (USDA, 1975). The average soil bulk density is 1.5 g cm<sup>-3</sup> and has a pH<sub>(CaCl<sub>2</sub>)</sub> of 4.2. The experimental site was under a grass/shrub fallow for at least three years before the start of the experiment.

### Trial design and management

A randomized complete block design (RCBD) with 10 treatments and 4 replications was used. The plot dimensions were 6 m x 5 m. The treatments were 1, 2, 3, or 4 t ha<sup>-1</sup> of cowdung alone, 2 t ha<sup>-1</sup> *Cassia spectabilis* alone and 2 t ha<sup>-1</sup> *C. spectabilis* in combination with 1, 2, 3, or 4 t ha<sup>-1</sup> cowdung. With an N concentration of 3.85 %, 2 t ha<sup>-1</sup> *Cassia* was estimated to provide 77.0 kg ha<sup>-1</sup> of N. At 1.12 % N concentration, varying rates of 1, 2, 3, and 4 t ha<sup>-1</sup> cowdung were estimated to supply 11.2, 22.4, 33.6 and 44.8 kg ha<sup>-1</sup> of N, respectively. All experimental units were subjected to uniform agronomic practices.

Ridging was done on 25<sup>th</sup> December, 1996. For plots that received *C. spectabilis* alone, the biomass was placed along the rows as marked and buried to make ridges. Where *C. spectabilis* and cowdung were combined, cowdung was placed on top of the *C. spectabilis* and ridges made. In the cowdung alone treatment the manure was placed along the rows and then buried under ridges. The control plots were prepared as farmers do by gathering the vegetative materials in rows and mounding them to form ridges. All plots were planted with an early maturing, open pollinated maize variety (MMV 400) as a test crop. All treatments in the experiment received half the recommended rate of 100 kg ha<sup>-1</sup> of compound D (10 N, 20 P<sub>2</sub>O<sub>5</sub>, 10 K<sub>2</sub>O) for basal and 100 kg ha<sup>-1</sup> of urea (46 % N) for top dressing.

## ANALYTICAL PROCEDURES

### Soil chemical analyses

Soil samples for chemical analysis were collected at a depth of 0-20 cm at the beginning (November, 1996) and end (June, 1997) of the experiment. All analyses were done at Misamfu Research Centre, except for plant and soil N concentration, which was done at the University of Zambia Soil Analysis Laboratory. Total N was determined by the Kjeldahl method (Bradstreet, 1965) while available P was analysed by the Bray 1 method (Schuffelen *et al.*, 1961) and the soil pH was measured in a 1:2 soil to CaCl<sub>2</sub> solution ratio. Organic C was determined by the Walkley Black method and K, Ca, Mg and Na were extracted in 1 M ammonium acetate (buffered at pH

7.0) and measured using by atomic absorption spectrophotometry.

### Plant tissue analyses

Maize plant samples were collected thrice during the growing season, at the 4-6 leaf stage, ear leaf stage and at maturity stage. At the 4-6 leaf stage, six randomly selected plants were used for nutrient analysis. The whole plant portion above the ground was sampled and analyzed since the stems were too rudimentary to be separated from the leaves. A sub-sample was weighed and analyzed for N, P, K, Ca and Mg using methods described by Anderson and Ingram (1993). In the second sampling six randomly selected plants were sampled and the leaf immediately below the lowest cob was used for analysis. If no cob/ear had developed, samples were collected from the sixth leaf from the bottom of the plant. Samples were processed using the same procedure described above. In the third sampling, only selected treatments were used for both leaf and stem samples. Six randomly selected plants were taken for nutrient analysis. The leaf immediately below the lowest cob was used. For stem samples, four internodes were taken from the internode immediately below the lowest cob. The plant samples were processed using the procedures described above.

Plant nutrient uptake was calculated on the basis of plant dry matter and nutrient concentrations (Walsh and Beaton, 1983). The plant nutrient uptake at the ear-leaf stage was not calculated because the data on the nutrient concentrations for the whole plant at this stage were not collected.

### Organic residue analysis

Leaf and twig samples taken from *Cassia* plants at the beginning of the trial were oven dried at 60° C and ground to pass through a 0.15 mm sieve. Cowdung samples were also collected from the heap prior to the commencement of the experiment and oven dried at 40° C to prevent volatilization of ammonium and ground to pass through 0.15 mm mesh. Carbon, N, P and K were analysed and the C/N ratio was calculated. All analyses were done according to procedures described above.

### Plant height and dry matter assessment

Height measurements were done at three time intervals; at the 4-6 leaf stage, at the ear leaf stage and at the maturity stage. Ten randomly selected plants per plot were chosen as a sample for taking plant height. Dry matter assessment was done only for the above-ground biomass and at three time intervals as for plant height. For this assessment, six randomly selected plants were taken from each plot. The rest of the plants in the plot were cut from the crown of the stem at ground level and weighed to obtain the plot fresh weight. Sub-samples were collected for assessing the dry matter yield per hectare according to Anderson and Ingram (1993).

### Statistical analysis

Data were subjected to analysis of variance (ANOVA) and means were separated using Duncan's Multiple Range Test and Orthogonal Contrasts.

**Table 1. Selected chemical characteristics of the Misamfu Red soil at trial establishment**

Depth (cm)	pH (CaCl <sub>2</sub> )	Org. C	Total N	Available P	C/N	Exchangeable cations						CEC
						K	Mg	Ca	Na	Exc. acid	Exc. Al	
		---- (%) ----		(mg kg <sup>-1</sup> )		----- (cmolc kg <sup>-1</sup> ) -----						
0-20	4.2	1.2	0.06	1.8	20	0.07	0.17	0.65	0.02	0.60	0.50	0.93

**Table 2. Selected soil chemical properties of six treatments at the end of the trial as affected by *Cassia* and cowdung applications.**

Grass fallow	Treatments		pH (CaCl <sub>2</sub> )	Org. C	Total N	Avail. P	C/N	Exchangeable cations						CEC
	Cowdung	<i>Cassia</i>						K	Ca	Mg	Na	Exc. acid	Exc. Al	
	(t/ha)	(t/ha)			(%)	(mg kg <sup>-1</sup> )		----- (cmolc kg <sup>-1</sup> ) -----						
Control			4.6	1.8	0.08	6.7	23.4	0.12	0.48	0.24	0.01	0.83	0.27	0.85
	1		4.3	1.7	0.08	6.5	21.7	0.11	0.30	0.19	0.02	0.90	0.30	0.62
	2		4.4	1.7	0.10	7.4	17.5	0.11	0.28	0.16	0.01	1.13	0.33	0.62
		2	4.3	1.6	0.08	9.1	20.4	0.10	0.28	0.13	0.03	1.13	0.33	0.54
	1	2	4.4	1.5	0.08	5.9	19.5	0.14	0.38	0.19	0.04	0.83	0.27	0.75
	2	2	4.3	1.6	0.08	8.9	18.9	0.10	0.24	0.12	0.04	1.13	0.30	0.50
LSD(0.05)			ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	Ns
CV (%)			4.7	12.1	16.18	43.5	26.3	22.3	45.1	49.9	26.0	31.5	30.4	22.8

ns=non significant at P = 0.05

**Table 3. Chemical characteristics of organic residues used in the study.**

Source	Org. C	N	P	K	C / N
	----- (%) -----				
Cowdung	38.9	1.12	0.40	0.06	34.7
<i>C. spectabilis</i>	47.6	3.85	0.37	0.16	12.4

## RESULTS AND DISCUSSION

### Soil chemical and organic residue analysis

There were no significant changes in soil chemical properties in the short run, but apparent changes in the soil nutrient status resulting from treatment effects were observed (Tables 1 and 2). In all the selected treatments, pH values were increased above those obtained before the treatments were imposed at the beginning of the experiment (Table 1 and 2). It was not well understood why the soil pH, organic carbon, Ca and Mg concentrations were highest in the control plot. There were no significant differences in soil N concentration, but appreciable increases from 0.06 % to 0.08 % were noticed. All the plots treated with either cowdung or *Cassia* were not different from each other in all parameters. The C/N ratio for the cowdung was 34.7 while that of the control was 12.4 (Table 3).

### Effect of organic matter treatments on maize plant height as affected by different manure amendments.

**Maize plant height at the 4-6-leaf stage, ear-leaf and maturity stages.** At the various stages, significant height differences ( $P \leq 0.05$ ) among the treatments were observed (Table 4). The general trend in growth was increasing height with increasing amounts of organic matter inputs. Plants treated with cowdung + *Cassia* were significantly ( $P \leq 0.05$ ) taller than those in other plots. Plots treated with *Cassia* had plants that were taller than those treated with cowdung alone and those in the control plot. Generally, there was an added

advantage of combining cowdung and *Cassia*, using cowdung alone or *Cassia* alone over the control.

### Effect of organic matter treatments on maize dry matter production

**Maize dry matter yield at the 4-6 leaf stage.** The biomass production was unusually low because of the unexpected drought and poor growth conditions experienced in the 1996 season. The dry matter increased as organic manure inputs increased. The order of mean dry matter yield was cowdung + *Cassia* > *Cassia* > the cowdung alone plots and least in the control (Table 5). Generally, all plants with combinations of cowdung and *Cassia* had significantly more ( $P \leq 0.05$ ) dry matter yield. All plants treated with cowdung alone, the control plots as well as those treated with *Cassia* alone did not show any significant differences in dry matter yield. The plants treated with *Cassia* alone responded much faster in dry matter build up than those amended with cowdung alone.

**Maize dry matter yield at the ear-leaf stage.** A combination of 4 t ha<sup>-1</sup> cowdung with 2 t ha<sup>-1</sup> *Cassia* green manure produced the highest DM yield whereas the lowest yield was obtained from the 1 ton ha<sup>-1</sup> cowdung alone (Table 4). The trend shown at 4-6 leaf stage for cowdung + *Cassia* treatment was exhibited at the ear-leaf stage. Plants in plots with cowdung + *Cassia* had significant dry matter increases over the rest of the treatments. There was a tendency for the dry matter yield to increase as organic matter inputs increased. The plants amended with *Cassia*

**Table 4. Height of maize plants at various growth stages in response to *Cassia* and cowdung applications.**

Treatments			Plant height		
Grass fallow	Cow-dung	<i>Cassia</i>	4-6 leaf stage	Ear leaf stage	Matur-ity
	(t ha <sup>-1</sup> )			(mm)	
Control			192	759	1513
	1		170	731	1460
	2		189	840	1507
	3		175	820	1438
	4		208	847	1519
		2	222	899	1557
	1	2	266	1084	1663
	2	2	310	1173	1673
	3	2	329	1231	1774
	4	2	361	134	1708
LSD (0.05)			39	160	176
CV (%)			11	11	7

alone generally gained more dry matter than plants in the control and the cowdung alone plots except for the 4 t ha<sup>-1</sup> of cowdung. The results obtained by Reddy *et al.* (1986) in which green manure increased maize dry matter over the fallow is in agreement with these findings.

**Maize dry matter yield at the maturity stage.** There were no significant differences ( $P \leq 0.05$ ) among the following treatments: the control, cowdung alone and the *Cassia* alone treatments. Plots with cowdung + *Cassia* gave significantly more dry matter yield over the control, the *Cassia* alone and the cowdung alone treatments (Table 5). The overall observation was that there were appreciable and in some cases significant dry matter yield increases in all manured plots.

**Table 5. Dry matter of maize stalks for different *Cassia* and cowdung applications at various stages of growth.**

Treatments			Dry matter		
Grass fallow	Cow-dung	<i>Cassia</i>	4-6 leaf stage	Ear leaf stage	Matur-ity
	(t ha <sup>-1</sup> )			(kg ha <sup>-1</sup> )	
Control			67	1542	1409
	1		70	1494	1403
	2		83	1569	1590
	3		72	1616	1286
	4		96	1894	1467
		2	88	1747	1832
	1	2	151	2694	2189
	2	2	197	2363	2144
	3	2	202	2741	2931
	4	2	231	2757	2717
LSD (0.05)			35	490	683
CV (%)			19	17	25

**Maize grain yield as affected by soil amendments of *Cassia* and cowdung.** The average maize grain yields were slightly lower than expected for MMV 400 whose yield potential is 3,500 kg ha<sup>-1</sup>. This could be attributed to late planting due to delayed onset of rains and the long drought experienced at the ear leaf stage. Generally, the grain yield

increased as the amount of organic residues increased and was more pronounced in the *Cassia* + cowdung treatments (Table 6). The 4 t ha<sup>-1</sup> cowdung + 2 t ha<sup>-1</sup> *Cassia* produced the highest grain yield. The grain yield in the treatment of *Cassia* alone outyielded the control by 10.4 %, though not significant. This, however, is in accordance with Bowen (1987) and Carsky (1989) who found that green manuring with different legumes especially *Mucuna* increased maize grain yield from 700 to 3,700 kg ha<sup>-1</sup> over the control. Our findings that cowdung application has no significant effect on the yield, are supported by Munguri *et al.* (1996) whose results on the effect of cattle manure on quantity and application method for cattle manure showed little or no effect on maize grain yield.

**Table 6. Maize grain yield in response to different *Cassia* and cowdung applications.**

Treatments			Grain yield
Grass fallow	Cowdung	<i>Cassia</i>	
	(t ha <sup>-1</sup> )		(kg ha <sup>-1</sup> )
Control			1582
	1		1170
	2		1180
	3		944
	4		1182
		2	1195
	1	2	1874
	2	2	1906
	3	2	2534
	4	2	2585
LSD <sub>0.05</sub>			1027
CV (%)			48

It was generally observed that the plants in the *Cassia* + cowdung plots were less affected by the long dry spells experienced at the ear leaf stage and subsequently gave higher maize yields than those in other treatments. The cowdung + *Cassia* (mean yield of 2,226 kg ha<sup>-1</sup>) significantly more than doubled the yield over the control, and significantly almost doubled the yield over the *Cassia* alone and cowdung alone treatments. These results are supported by the findings of Agbim (1981, 1985, 1988) who obtained positive responses by combining plant and animal waste combinations of cassava peels and cattle dung on the intercropping yields of yam and bean. It is observed that the results show some possible synergistic effects. The combined effect of cowdung + *Cassia* seemed to be greater than the sum of their separate effects. For instance, the yield from the combined application of 4 t cowdung + 2 t *Cassia* was greater than the sum of individual treatments of 4 t cowdung and 2 t *Cassia*. It is expected that the release of nutrients from the *Cassia* with a low C/N ratio in the early stages was complemented by the continued release from the cowdung as a slow release fertilizer. Such treatments with a combined effect are more likely to synchronize the nutrient release from the organic residues with plant nutrient demand.

#### Nutrient concentrations in maize at the 4-6 leaf, ear leaf and maturity stages as affected by soil amendments of *Cassia* and cowdung

There were no significant effects of the organic matter treatments on the plant tissue concentrations of N, P, K, Ca and Mg at all the three growth stages (Tables 7).

**Table 7. Mean nutrient concentrations in maize plants or components at various growth stages\***

Whole plant or components	N	P	K	Ca	Mg
			(%)		
4-6 leaf stage	1.06	3.49	5.63	0.81	0.44
Ear-leaf stage	0.72	0.20	5.01	1.12	0.35
Stem at maturity	0.73	1.74	1.56	0.34	1.27
Leaf at maturity	1.15	2.30	2.05	0.91	1.68
Grain at maturity	1.66	0.12	0.06	0.18	0.09

\* treatments effects not significant at p=0.05

**Plant macro nutrient uptake by maize as affected by soil amendments of *Cassia* and cowdung**

**Plant macro nutrient uptake by maize at the 4-6 leaf stage.** The uptake of nitrogen was lowest in the control and highest under 2 t ha<sup>-1</sup> *Cassia* + 1 ton ha<sup>-1</sup> cowdung. It was observed that plants treated with either *Cassia* alone, cowdung alone or a combination of cowdung + *Cassia* had higher uptake values than the control (Table 8). This perhaps suggests that organic manure contributed to the increased N uptake in the manured plots rather than the control though there could be other factors. The trend in the uptake of N within the cowdung alone or the cowdung + *Cassia* plots was not defined. Plants treated with cowdung alone and *Cassia* alone had similar N uptake. There was no trend in P and Ca uptake among all treatments though higher in the treatments with cowdung + *Cassia*. The uptake of P in the cowdung + *Cassia* plots was almost twice as much as that in the cowdung alone. There was a distinct trend in K uptake for all treatments that received of *Cassia* + cowdung manure. The uptake of K increased with increasing levels of organic manure application. A similar trend to that of K was observed for Mg. The uptake for the 2 t ha<sup>-1</sup> *Cassia* + 4 t ha<sup>-1</sup> cowdung was significantly higher than the control, the cowdung alone and the *Cassia* alone treatments. The significant increase in K and Mg uptake especially for the treatment with cowdung + *Cassia* might explain the plant growth vigour visually observed in these treatments.

**Table 8. Plant macronutrient uptake by maize leaves for different *Cassia* and cowdung applications at the 4 - 6 leaf stage**

Grass fallow	Treatments		Nutrient uptake				
	Cow-dung	<i>Cassia</i>	N	P	K	Ca	Mg
	(t/ha <sup>-1</sup> )		(kg ha <sup>-1</sup> )				
Control			1.3	0.50	0.30	0.03	0.01
	1		2.2	0.32	0.28	0.02	0.01
	2		2.0	0.34	0.33	0.03	0.01
	3		1.5	0.33	0.29	0.02	0.01
	4		2.0	0.50	0.42	0.04	0.01
		2	1.7	0.45	0.35	0.03	0.01
	1	2	5.2	0.60	0.81	0.06	0.02
	2	2	3.1	1.20	0.94	0.07	0.02
	3	2	4.1	0.71	0.95	0.06	0.03
	4	2	3.5	0.54	1.10	0.06	0.03
LSD (0.05)			2.4	ns	0.33	ns	0.01
CV (%)			62	70	40	69	66

ns=non significant P = 0.05

Generally, the uptake of N, K and Mg were enhanced in treatments of *Cassia*, cowdung and their combination.

**Plant macro nutrient uptake by maize at the maturity stage.** There were no significant differences among the treatments in the overall plant nutrient uptake at the end of the growing season (Table 9). It is possible to obtain such results in the first cropping season when organic manures are incorporated until there is a build up effect in the long term. However, plant uptake in treatments of *Cassia* green manure and cowdung + *Cassia* were slightly more than the control for all the nutrients. The data generally indicate that there was some advantage in incorporating *Cassia* alone and also combining cowdung and *Cassia* manures to the soil. The uptake of all nutrients in the *Cassia* treatments was greater than that of cowdung alone treatment possibly because the contribution in terms of nutrient release from *Cassia* was more effective, being a relatively fast decomposer, than that from the cowdung, which, is a slow release fertilizer. The general performance of the maize from the combination of cowdung and *Cassia* was better than that of the other treatments possibly due to the combined effect of the two organic sources.

Generally, the uptake of N decreased while that of P, Ca and Mg increased with plant maturity. The N uptake could be lower probably due to leaching and volatilization losses as a result of long dry spells experienced at the beginning of the season followed by heavy rains received during the mid and towards the end of the season (Fig. 1).

**CONCLUSION AND RECOMMENDATIONS**

The potential for incorporating both plant and animal wastes to improve soil physical and chemical properties to provide a conducive maize growing environment exists. Appreciable increases in the soil pH, organic C, N, P, plant uptake of N, K, Mg, reduced exchangeable aluminium and significant increases in dry matter as well as grain yield observed in especially plots receiving cowdung, + *Cassia* are adequate indications of the importance of these organic amendments.

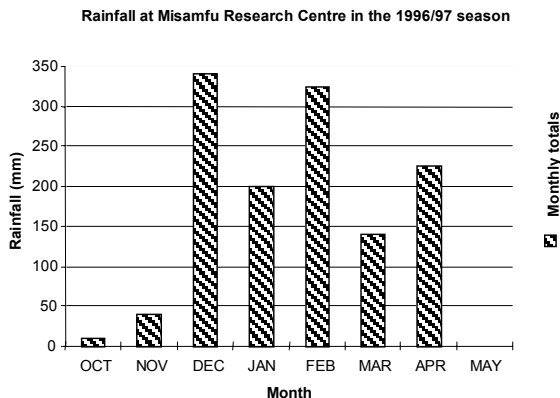
Studies to establish the true economic value of the organic materials used in the trial were not done. This therefore leaves room for future investigations to determine the socio-economic aspects of the various procedures of collecting, processing and distribution/application of organic fertilizers.

**Table 9. Plant uptake of major nutrients in maize as affected by different *Cassia* and cowdung applications at the maturity stage**

Grass fallow	Treatments		Nutrient uptake				
	Cow-dung	<i>Cassia</i>	N	P	K	Ca	Mg
	(t/ha <sup>-1</sup> )		(kg ha <sup>-1</sup> )				
Control			50	86	58	39	53
	1		47	73	52	26	43
	2		50	67	62	29	53
		2	58	85	72	36	66
	1	2	71	80	87	47	71
		2	64	69	70	41	62
LSD (P ≤ 0.05)			ns	ns	ns	ns	ns
CV (%)			25	43	34	42	31

ns=non significant P = 0.05

**Figure 1. Rainfall at Misamfu during the experimental period.**



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