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# Evaluation of Siam and Mimosa Bioherbicides as Alternative Weed Control in Cowpea (*Vigna unguiculata* (L.) Walp.) Production

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## Abstract

*This study aimed at evaluating the potentials of Siam and Mimosa weeds as bioherbicides along with a chemical herbicide, Force-Uron and their combinations for weed control efficacy, growth and nodulation of cowpea (Vigna unguiculata). It was a pot experiment carried out at the Farm House of the School of Agriculture and Industrial Technology, Babcock University, Ilishan-Remo, Ogun State, Nigeria with six treatments, namely: Control (no herbicides), chemical herbicide (Force-Uron) applied sole at 4 liters/ha, Siam weed (bioherbicide) applied sole at 30 kg/ha, Mimosa weed (bioherbicide) applied sole at 30 kg/ha, 50:50 chemical herbicide/ bioherbicide (Siam weed) and 50:50 chemical herbicide/ bioherbicide (Mimosa weed); with four replications in a Completely Randomized Design (CRD). Results showed that Siam bioherbicide was superior in terms of weed control, stimulation of higher nodule weight and higher cowpea shoot, tissue N concentration than the Mimosa bioherbicide. The applications of the two 50:50 chemical herbicide/bioherbicide combinations showed higher efficacy in weed control in terms of low weed count and dry matter weight, as well as nodulation especially nodule dry weight, than the application of the sole herbicide types- an expression of synergy in respect of combined use of chemical herbicide and bioherbicides.*

**Key words**: Allelopathy, weed management, nodule, shoot weight.

## Introduction

Cowpea originated in Africa, Latin America, and Southeast Asia and in the Southern United States (Davis, 1991). It is an important food in West Africa, especially in Nigeria where it forms an important dietary item which provides protein supplement for the high caloric food of Nigerians (Raheja, 1986). The grain contains 24.8% protein, 1.9% fat, 6.3% fibre, 63.6% carbohydrate, 0.00074% Thiamine, 0.00042% Riboflavin, 0.00281% niacin (Davis, 1991). Cowpea is one of the grain legumes capable of fixing atmospheric $N_2$ in symbiosis with soil bacteria of the genus *Bradyrhizobium*. Through this type of nitrogen biotransformation, legumes derive some of their nitrogen requirement and also benefit the companion or subsequent crops. The use of fixed nitrogen for improving crop yield and soil fertility is a cheaper substitute to the use of the expensive inorganic nitrogen fertilizer. However, many environmental conditions (aerial and soil) and biotic factor influence the ability of *V. unguiculata* and other legumes to fix nitrogen optimally (Singh *et al.*, 1983). The plant tolerates drought, performs well in a wide variety of soils and, being a nitrogen-fixing legume, and replenishes low fertility soils when the roots are left to decay. Cowpea is grown mainly by small-scale farmers in developing regions where it is often cultivated with other crops as it tolerates shade. It also grows and covers the ground quickly, thus controlling erosion. In Nigeria, the crop is grown throughout the country with the highest cultivation recorded in northern states. Arising from its wide acceptance for cultivation in Nigeria, the country was rated the world's largest producer (FAO, 1986). According to Akobundu (1978), cowpea is rarely grown in pure stands (sole) but oftentimes, it is intercropped with cassava, sorghum, millet and maize.

Apart from applying starter N and phosphorus to grain legumes like cowpea, to boost symbiotic N2 – fixation (Kang and Nangju, 1983), weed control is crucial. Weeds can be pulled by hand and/or removed by hoeing (physical control method) and through application of herbicides (chemical control method). Herbicides are very costly and out of the reach of Nigerian low-resource farmers. In addition, herbicide residues can pollute a soil system and some can be passed into the food-web and eventually eaten by humans, causing health problems. It is most probable that some weeds growing around us could exhibit herbicidal properties if exploited through research. In this connection, there are few common weeds growing around the Teaching and Research Farm of the School of Agriculture and Industrial Technology Babcock University, Ilishan-Remo namely: Mimosa (*Mimosa pudica,* L.) and Siam (*Chromolaena odorata,* L.) weeds which grow aggressively to suppress the growth of other weeds; thus, suggesting that they exhibit suppressive allelopahatic or herbicidal property. Mimosa is a leguminous, thorny semi-erect weed found growing in many parts of the states of Nigeria. Siam weed (*Chromolaena odorata*) is considered one of the world's most invasive weeds. In its habitat, Siam weeds are known to exhibit residual activities because other weeds are permanently suppressed as long as Siam continues to grow. It is yet to be investigated if the residual attribute would be experienced whenever used as organic herbicides (bioherbicides) because of its apparent rapid decomposition; being a broad leaved weed.

There is always an erratic supply of synthetic agrochemicals including herbicides to Nigerian farmers as a result of poor distribution network. On application, herbicides are known to exert deleterious effect on non-target crop plants along with weed-kill. For instance in a study, Daramola (1980) found that a chemical herbicide hindered the efficiency of legume- *Rbizobium* partnership in a biological nitrogen fixing system. Consequently, it is pertinent to investigate the possibility of adopting weeds like siam and mimosa which have the capacity to exhibit persistent allelopathic attribute on their weed companion. Silver (2010) stressed the efficacy of Moringa leaves incorporated into a soil for the control of damping-off disease. It is therefore expedient for agronomists too to investigate the possibility of adopting the above- named weeds (Siam and Mimosa) as bioherbicides in crop production systems. In the same way *Carica papaya* (L.) (pawpaw) has been adopted for its insecticidal property on *Callosobruchus maculatus* - an insect of stored cowpea (Adenekan *et al.*, 2007). The potential of leguminous leaf meal on livestock production has been found (D'Mello, 1992). Also, the adoption of locally sourced botanicals in crop production either as organic fertilizers or pesticides or in livestock nutrition in accordance with the principles of organic farming which emphasizes reliance on natural pest and disease control without use of synthetic input (Ziesemer, 2007). Apart from possibility of reducing cost of production, the use of locally available botanicals is a more environment-friendly option than application of agro-chemicals which may generate residue problems in a soil or/and human systems. Therefore, this research was designed to evaluate Siam and Mimosa weeds for their probable herbicidal properties along with a chemical herbicide (Force-Uron) and the combinations of the two options on weed control efficacy, growth and nodulation of Cowpea Ife brown variety.

## Materials and Method

### Location of the Experiment and Soil Used

The pot experiment was carried out at the premises of the Farm House, School of Agriculture and Industrial Technology, Babcock University, Ilishan-Remo, Ogun-State between December 2012 and February 2013. This location is in the South Western part of Nigeria with an annual rainfall of 1,500 mm, a mean annual sunshine of about 2,100-2,300 hours and a mean annual temperature of about 27°C. Several core soil samples (0-15cm) were collected randomly from a fallow overgrown with a mixture of grasses, sedges and broad-leaved weeds. The core samples were bulked, thoroughly mixed, shade-dried and sieved through a 2-mm screen after which a composite sample was taken for analysis at the Institute of Agricultural Research and Training (Ibadan), Soil Science Laboratory for some physico-chemical characteristics (Table 1). Available phosphorus was determined according to the method of Bray and Kurtz (1945); total N was determined by the macro Kjeldahl method described by Bremmer and Malvancy (1982); soil pH (1:1 soil: water) was determined by the pH meter, the organic carbon was determined by the method described by Walkely and Black (1934) and the mechanical analysis was done by the hydrometer method described by Bouyocous (1962). Basal fertilization of 40 kgP/ha as Single super phosphate (8.8% P), 30 kgK/ha as Murate of Potash (60% K) and 20 kgN/ha starter dose of Urea (45% N) were done by mixing the fertilizers into the bulk sieved soil. Thereafter, five (5) kilograms of sieved soil were filled into basally perforated plastic buckets, surface area of 3.0 cm² and moistened with tap water.

### The treatments

There were six (6) treatments namely:

A – Control (No herbicide)

B- Chemical Herbicide CH, 4 l/ha sole
(Force-Uron)

C- Marshed Siam weed (SW) – 30 kgSiam/ha sole
(Bioherbicide)

D- Marshed Mimosa weed (MW) – 30 kgSiam/ha sole
(Bioherbicide)

E- 50:50 Chemical Herbicide (CH) / Bioherbicide (SW)

F- 50:50 Chemical Herbicide (CH) / Bioherbicide (MW)

The above – named treatments were replicated four times using a completely randomized design (CRD).

### Cowpea Seeds, Sowing and Herbicide Application

Cowpea seeds (Ife Brown variety) were obtained from the seed store of the Institute of Agricultural Research and Training, Moor Plantation, Ibadan. A week before seed sowing (5 seeds per pot) into a pre-moistened soil, a pre-planting application of a solution of the chemical herbicide and slurries of 30 kg/ha each of marshed siam and mimosa respectively were applied to the surface of the soil in the pre-labelled pots.

**Data Collection**
Data were collected on the following characteristics:

- Plant growth in terms of height at 4 and 6 weeks after planting (WAP).
- Nodule parameters; number and dry weight at 4, 6 and 8 WAP.
- Weed pressure variables; weed count and dry weight of weeds at 4 and 6 WAP.
- Dry matter weight of roots and shoots (separately) at 6 and 8 (WAP).
- Tissue %N (in cowpea shoot) at 6WAP.

The nodules, roots and shoots were put in separate envelopes and oven-dried at 80°C for 48 hours or to constant dry matter weights.

**Data Analysis**
Analysis of variance (ANOVA) was carried out on the data collected, in order to test for significance of treatments using Statistical Analysis System (SAS Institute, 1999) and employing the method outlined by Steel and Torrie (1980). Means from significant treatments were then separated by Duncan Multiple Range Test (DMRT) at 5% level of significance.

**Results and Discussion**
**The pre-crop soil physico-chemical properties**.
Based on the particle size analysis values, the soil used for the trial is Sandy loam (Table 1).

**Table 1: Pre-crop soil physico-chemical properties.**

| Soil properties | Amount |
|---|---|
| **pH (1:1 Soil/Water ratio)** | 6.78 |
| **Available P (ppm)** | 13.6 |
| **Nitrogen (%)** | 0.20 |
| **Carbon (%)** | 0.71 |
| **Calcium (Cmol/kg)** | 3.30 |
| **Magnessium (Cmol/kg)** | 0.69 |
| **Potassium (Cmol/kg)** | 0.18 |
| **Sodium (Cmol/kg)** | 0.52 |
| **Sand (%)** | 79.2 |
| **Silt (%)** | 11.4 |
| **Clay (%)** | 9.4 |
| **Textural Class** | Sandy loam |

The Sandy loam nature of the soil could be responsible for its low %C of 0.71 (Table 1), an equivalent of 1.22% organic matter (low) and a probable corresponding by low organic colloid which may explain the generally low bases namely: ($Ca^{2+}$, K+, $Mg^{2+}$ and Na+) due to leaching. Soil organic matter and microbial biomass are important soil quality indicators (Oluwatosin *et al*., 2008). The soil used was slightly acid and this may account for the medium total soil N and available P (Singh, 2002). The soil used for the study can thus be classed as low in nutrients; belonging to a soil Order Ultisols (Brady and Weil, 1999).

**Plant Height**

Results on plant height as influenced by the application of chemical herbicides and the botanicals as bioherbicides are presented in Table 2.

**Table 2: Mean performance of chemical herbicides and bioherbicides on cowpea plant height at two sampling periods**

| | 4WAP | 6WAP |
|---|---|---|
| **Treatments** | **Plant height (cm)** | **Plant height (cm)** |
| Control | 33.50ab | 43.00ab |
| CH (sole) | 27.50b | 36.00b |
| SW Bioherb (sole) | 34.25a | 35.50b |
| MW Bioherb (sole) | 34.00ab | 45.00ab |
| 50:50 CH /SW Bioherb | 29.50ab | 47.25a |
| 50:50 CH/MW Bioherb | 30.00ab | 40.00ab |

Means followed by same letters within a column are not significant (DMRT 5%)

For all treatments, plant height increased with age. The increase in plant height within a fortnight being most spectacular (60%) with 50:50 combination of the chemical herbicide and the Siam bioherbicides suggesting a synergy between the two herbicide types (chemical and organic) in enhancing plant growth in terms of height. At 4WAP, application of the chemical herbicide (Force-Uron) depressed cowpea (Ife Brown variety) seedling height relative to the other treatments; the depression being significant (5%) when compared to sole application of Siam bioherbicide (Table 2). However, the subsequent 31% increase in plant height (6WAP) with the chemical herbicide application suggested that the depression in the cowpea height at 4 WAP was merely transitory. Though on cowpea root growth, Daramola (1980) observed a similar transitory depression with application of Dual (a chemical herbicide).

**Weed parameter (count and weight (g))**

The effects of application of a chemical herbicide and the two bioherbicides (Siam and Mimosa) on weed count and weight (4 and 6 WAP) are presented in Table 3.

**Table 3: Mean performance of chemical herbicides and bioherbicides on weed count and weight at two sampling periods**

| | 4WAP | 6WAP | |
|---|---|---|---|
| **Treatments** | **Weed count (per pot)** | **Weed count (per pot)** | **Weed weight (g) (per pot)** |
| Control | 22.50a | 21.00a | 97.39a |
| CH (sole) | 1.00b | 3.50b | 41.83bcd |
| SW Bioherb (sole) | 22.50a | 18.50a | 83.86ab |
| MW Bioherb (sole) | 22.00a | 20.50a | 70.18abc |
| 50:50 CH / SW, Bioherb. | 0.50b | 0.50b | 3.72d |
| 50:50 CH/MW, Bioherb | 2.00b | 2.25b | 22.46cd |

Means followed by same letters within a column are not significant at 5% level of probability.

The application of the chemical herbicide (Force-Uron) and the two 50:50 combination of the chemical herbicide and each of the bioherbicides significantly (5% level) depressed weed count compared separately to the control treatment. Notably, the application of the 50:50 combination of chemical herbicide/Siam bioherbicide almost resulted in a total weed kill relative to either the sole herbicide or the sole bioherbicide application and to the second 50:50 chemical herbicide/Mimosa bioherbicide option at both 4 and 6 WAP-a manifestation of synergy. There was a general reduction in weed count between 4 and 6 WAP with the application of sole bioherbicides and when combined with the chemical herbicide (Table 3). A similar weed count reduction was not evident with application of the chemical herbicide depicting that the bioherbicides had residual effects on weed control. It is apparent that the bioherbicides killed some weed seedlings between the two sampling periods and disallowed further weed flush unlike the situation under chemical herbicide application.

At 6 WAP, weed count under Siam bioherbicides was lower though non-significant than with Mimosa bioherbicide application; indicating a probable superior efficacy in weed control by Siam over the Mimosa. Based on weed count, the sole application of the chemical herbicide was more efficient in weed control than the sole bioherbicides. As regards weed weight, sole applications of chemical herbicide and its combinations with each of the bioherbicides resulted in significantly lower weed weight compared separately with the control treatment (Table 3).

Application of each of the combinations resulted in marked lower weed weight compared to any of the herbicide types in the combinations. It appears that the combined application disrupted certain weed physiological functions which probably accounted for the depressed dry matter accumulation expressed as lowered weed weights with the applications of the combined option (a synergy). Though on human health sector, a similar synergy was obtained in Benin, West Africa and Waganingen in Netherlands (African Review, 2011), where a chemical insecticide was used in combination with fungal spores to effectively control resistant malaria mosquito.

**Nodule Count and Dry Matter Weight (g)**

The results of nodule parameters namely: count and weight are recorded in Table 4.

**Table 4: Nodule Count and Dry Matter Weight responses to application of chemical herbicides and bioherbicides at two sampling periods**

| PLANT NODULATION | | | | | |
|---|---|---|---|---|---|
| | 4WAP | 6WAP | | 8WAP | |
| **Treatment** | **Nod. No** | **Nod. No** | **Nod. Wt** | **Nod. No** | **Nod. Wt** |
| Control | 12.50a | 15.25ab | 0.08ab | 19.250ab | 0.49a |
| CH (sole) | 2.75a | 9.75b | 0.06b | 14.75b | 0.41a |
| SW Bioherb (sole) | 13.00a | 18.25a | 0.10ab | 24.25a | 0.66a |
| MW Bioherb (sole) | 13.75a | 14.00ab | 0.11ab | 17.50ab | 0.56a |
| 50:50 CH / SW Bioherb | 10. 25a | 11.50b | 0.10ab | 13.00b | 0.54a |
| 50:50 CH/MW Bioherb | 4.00a | 13.75ab | 0.23a | 20.50ab | 0.68a |

Means followed by same letters within a column are not significant at 5% level of probability.

At 4WAP, there was no significant reduction in nodule number with application of any of the herbicides (chemical or organic) relative to control treatment. However, separate applications of chemical herbicide sole and its combination with Mimosa bioherbicide resulted in markedly lower nodule counts compared to any of the other treatments. But, plant nodule count was highest with sole application of Mimosa bioherbicide followed by nodule count with sole application of Siam bioherbicide showing stimulatory effects of the two bioherbicides (sole) on the variable (4WAP). Similarly at both 6 and 8 WAP, application of Siam bioherbicide resulted in highest nodule count relative to any other treatment, with the count being significantly at (5%) higher compared to the counts under sole chemical herbicide and its combination with siam bioherbicide. At 8 WAP, the combined application of chemical herbicide and Mimosa bioherbicide resulted in higher nodule count than the separate application of either of the types of herbicide. This result indicated a synergistic effect of combined application of a chemical and a botanical herbicide. Application of all the bioherbicides, sole or in combination with chemical herbicide resulted in higher nodule weight at 6 and 8 WAP compare to sole chemical herbicide and control treatment respectively; indicating the potentials of Siam and Mimosa as bioherbicide. Even application of 50:50 chemical herbicide/mimosa bioherbicide 6 WAP resulted in 65% higher nodule weight than the control. In contrast, application of chemical resulted in lower nodule weight than the control treatment. Application of the sole chemical herbicide resulted in a significantly lower nodule weight compared to the combination. Nodule weight rather than number is a more reliable index of nodule effectiveness in a low N soil. The implication of the results in respect of cowpea nodulation was that generally, each of the bioherbiceds and their combinations with chemical herbicide (Force-Uron) entered for this study showed better promises than sole chemical herbicide and the same applies to weed control and plant growth in height (Tables 2 and 3).

**Root and Shoot Dry Matter Weight (g)**

The data in respect of root and shoot dry matter weights are presented in Tables 5 for 6 and 8 WAP.

**Table 5: Root and Shoot Dry Matter Weight responses to application of chemical herbicides and bioherbicides at two sampling periods**

| | 6WAP Dry Matter Weight(g) | | 8WAP Dry Matter Weight(g) | |
|---|---|---|---|---|
| **Treatments** | **Root** | **Shoot** | **Root** | **Shoot** |
| Control | 0.31b | 2.40bc | 0.45b | 4.45bc |
| CH (sole) | 0.41ab | 1.59c | 0.87ab | 3.10c |
| SW Bioherb (sole) | 0.74ab | 4.35ab | 1.24a | 5.87ab |
| MW Bioherb (sole) | 0.63ab | 4.53ab | 0.92ab | 6.13ab |
| 50:50 CH / SW, Bioherb | 0.62ab | 5.32a | 1.04a | 6.85a |
| 50:50 CH/MW, Bioherb | 0.80a | 4.57ab | 1.36a | 6.69a |

Means followed by same letters within a column are not significant (DMRT at 5% level of probability)

At 6 WAP, none of the herbicide types of application caused depressed root growth. Applications of the bioherbicides sole and in combinations with the chemical herbicide (Force-Uron) entry yielded higher root mass than the control and the sole chemical herbicide application A similar trend presented itself at 8WAP during which applications of all the herbicides types yielded higher root mass compared to the control. The root mass (8WAP) doubled with application of chemical herbicide indicating that the herbicide might have released some growth stimulatory factor(s) into the rhizoshpere. Significantly more massive rooting (5% level) was obtained with sole Siam bioherbicide and the combinations of each of the two bioherbicides and chemical herbicide respectively compared to the control. The two combinations of the chemical herbicides and each of the bioherbicides significantly depressed weed counts relative to the control treatment (Table 3). Massive rooting is very crucial to legume nodulation because the infectible sites for nodulation are located on the roots. The root massiveness obtained through siam bioherbicide application Table 5 translated to greater nodule number 8WAP (Table 4). Similarly, the root growth massiveness with 50:50 chemical herbicide/mimosa bioherbicide in Table 5 (8WAP) apparently expressed as a higher degree of nodulation: nodule weight and number (though non-significantly) at 6 and 8 WAP (Table 4) than either with separate applications of sole chemical herbicide and sole mimosa bioherbicide application, indicating a synergy with combined application of chemical herbicide (Force-Uron) and an organic herbicide, Mimosa. The synergy would probably result in reduced expenses on purchase of chemical herbicide by resource-poor farmers in Nigeria and hence reduce the extent of soil pollution through chemical herbicide residue.

Significant reductions ( at 5% level of probability) in shoot dry matter accumulations were obtained with the application of chemical herbicide (Force-Uron) used at both 6 and 8 WAP (Table 5) compared to application of any of the sole bioherbicides (Siam and Mimosa) and their combinations with the chemical herbicide. The results further demonstrated the potentials of sole applications of the bioherbicides (Siam and Mimosa) studied to promote the vegetative growth and nodulation of the cowpea test crop. Combined application of chemical herbicide with Siam bioherbicide resulted in greater shoot dry matter accumulation relative to separate applications of Siam and the chemical herbicide (Table 5) at 6 and 8 WAP.

**Shoot Tissue N Concentration**

The shoot tissue N concentration of cowpea is presented in Fig 1. Except with the application of mimosa bioherbicide, tissue N concentrations with the application of either types of herbicides or their combinations resulted in virtually same N concentrations compared to the control - indicating no inhibitory influence of application of either the chemical or the organic herbicides on the variable. In a low nutrient soil (order Utisols used for the trial), legume tissue N can be attributed to N2 fixation (Brady and Weil, 1999).

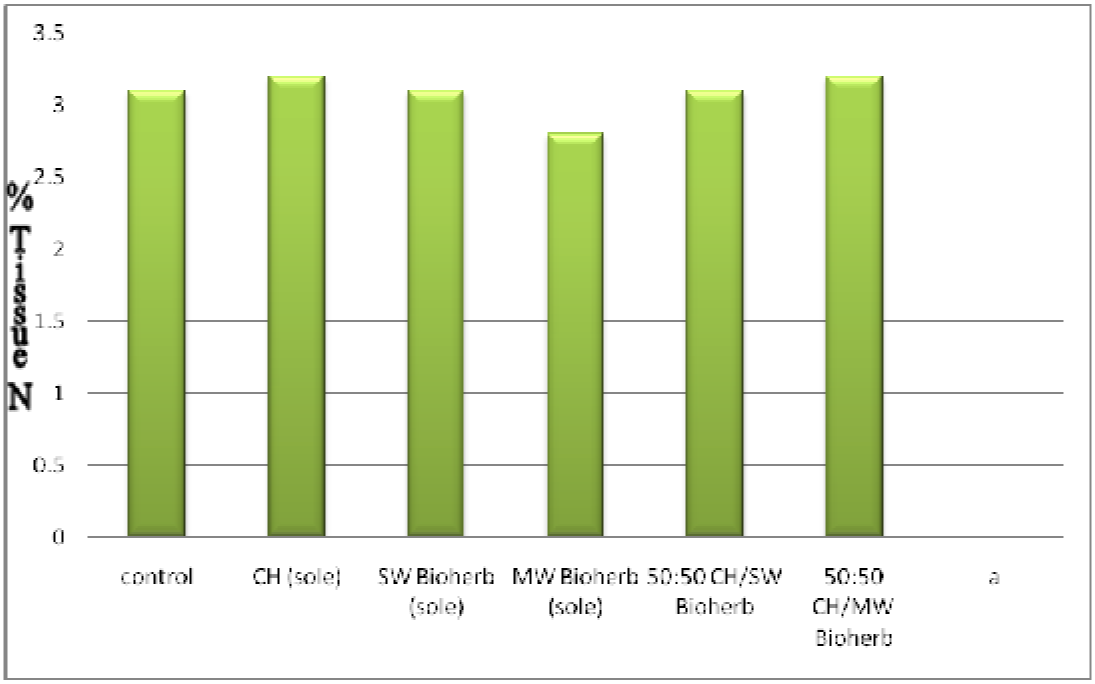


**Fig 1: Percentage tissue N response to application of Chemical herbicide, Siam and Mimosa bioherbicides.**

## 4.0 Conclusion

Generally, application of the two 50:50 chemical/bioherbide combinations was as markedly effective as chemical herbicide. For example, the combined application showed superior efficacy on weed control in terms of lower weed count and weight compared to sole application of either of the two bioherbicides namely :Siam and Mimosa - an expression of synergy of combined application of the chemical herbicide (Force-Uron) and either of the two bioherbicides (Siam and Mimosa) to the cowpea; Ife Brown. Specifically, the consistently higher dry nodule weight obtained at both the late vegetative and reproductive growth stages with application of the 50:50 chemical herbicide/Mimosa bioherbicide compared to the sole application of the bioherbicide (Mimosa), the chemical herbicide and the control treatment (no herbicide application) stressed the synergy. However as regards application of bioherbicides, sole Siam bioherbicide application was found to be superior to sole Mimosa in terms of stimulation of higher nodule weight and shoot tissue N concentration of the cowpea; the two reliable indices of nodule effectiveness(Nitrogen fixation) of legumes in a low to medium soil N status. Further studies may concentrate on the effect of the above treatments on the yield of other grain legumes.

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