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Integrated System for Cashew Disease Management and Yield

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Keywords

Cashew, dieback, severity index, fungicide, botanical species, yield

Abstract

Cashew is an important fruit tree majorly cultivated for edible nuts which provides income to farmers. Productivity and quality of the nuts are threatened by disease infestation; major fungal disease that affects cashew is inflorescence dieback caused by *Lasiodiplodia* species. Huge crop losses are recorded and problem intensified due to dearth of information on its management in Nigeria. Carbendazim, Mancozeb, extracts of *Ageratum conyzoides*, *Carica papaya*, *Chromolaena odorata* were used in spray application to manage the disease. Records of dieback incidence, severity index, disease reduction and nut yield were taken. Data were analyzed using SAS and mean difference were compared using Duncan Multiple Range Test. The treatment types showed efficacy to reduce incidence, dieback severity and improved yield. Cashew trees treated with integration of mancozeb with *C. odorata* was consistently higher in severity but produced highest nut yield in 2013 and 2015 seasons. The nut yield record was higher in trees treated with *A. conyzoides* and *C. papaya*-only compared to *C. odorata*, however cashew nut yield was generally higher in integrated systems. However, most effective system that improved yield were integration of Mancozeb with *C. odorata*, Carbendazim with *A. conyzoides*, Carbendazim with *C. papaya* and integration of Mancozeb with *A. conyzoides*.

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1. Introduction

Cultivation of cashew tree (*Anacardium occidentale* L.) takes place in more than 32 countries of the world and the priority is on the nut. Cashew is one of the important fruit trees in all producing countries across the globe [1,2]. Africa produces 40% of the total raw nut in the world and 80% of the production are obtained in West Africa. The yield of cashew is however low compared with the expected optimum of around 2.0 t/ha. Despite the economic viability of this crop, there are constraints to its production which also compromise the yield. The reasons for the decline in cashew nut production are linked to drought, declining soil fertility, unimproved low yielding genotypes, insect pests and diseases which are the most damaging and compromise the cashew nut yield in terms of quality and quantity [3,4,5,6]. Many pathogens infect different parts of cashew plant, varying from leaves, inflorescences, twigs, apples and nuts causing substantial economic losses [7]. Cashew is susceptible to over ten diseases caused by fungi [5,8]. These pathogens are site specific and compromise the yield of cashew nut in terms of its quantity and quality. Although data on cashew pathogens have not been properly documented and made

available in Nigeria, these pathogens have contributed to considerable yield lost in the crop. Cashew diseases have been identified as major factor of high production costs, poor nut quality and low market price of the crop. Such diseases include anthracnose caused by *Colletotrichum gloeosporioides*, black mold by *Pilgeriella anacardii*, angular leaf spot by *Septoria anacardii*, and floral and twig dieback caused by *Lasiodiplodia theobromae*. Inflorescence and twig dieback by *Lasiodiplodia theobromae* is a major factor limiting cashew nuts production in Nigeria [9]. An average yield loss to *Lasiodiplodia theobromae* infestation was estimated as 40-50%; and the diseases is designated as serious one which could cause reduction of nut yield by 70% and more than 50% death of vegetative shoot [10,11].

Information of statuses of diseases affecting cashew and their management strategies are vital for stakeholders in cashew value chain in Nigeria. Collective efforts to address cashew disease problems could involve plant breeders and pathologists to develop resistant crop varieties and integrated pest management options, respectively to combat diseases. The management of cashew diseases requires understanding of the season vis-à-vis the stage of growth and parts of plant affected while prompt action is important to control and limit production losses. The objective of the

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study is to develop eco-friendly and effective integrated strategy to manage dieback disease in cashew.

2. Materials and Methods

Study areas and treatment types:

This study on management of cashew diseases was done over three consecutive years on cashew plantation located in one of the major cashew growing States. The plot is located in Onigambari Forest Reserve (Lat. 7.2101°N, Long. 3.8669°E), Ibadan, South Western, Nigeria. The mean maximum temperature during the cashew season in the three consecutive years of field trials range from 27.4 °C to 28.4 °C, 27 °C to 34.1 °C and 32.4 °C to 34.39 °C respectively and were within the required limit except during flower initiation in November and December 2013, which recorded maximum mean temperature below 20 °C accounting for yield reduction in 2014 fruiting season. Similarity in mean temperature were observed during flower initiation in 2012 and 2014. The actual fruiting season of cashew takes place during the dry season in Nigeria and this season overlap calendar year. The studies were conducted between November each year and April of the following year covering the cashew flowering and fruiting season per year. Naturally infected cashew trees showing typical symptoms of inflorescence dieback were selected randomly and tagged in a randomized complete block design (RCBD). Field assessments of active ingredients (mancozeb 80% WP, carbendazim 50% WP) and botanical extracts (*Chromolaena odorata*, *Carica papaya* and *Ageratum conyzoides*) against inflorescence die-back of cashew were conducted under natural field infection conditions without artificial inoculation.

Preparation of aqueous botanical extracts:

Freshly identified leaves of *A. conyzoides*, *C. papaya* and *C. odorata* with established antifungal properties were collected from their natural habitats, washed under running tap three times and allowed to drain before extraction. The botanical species were weighed according to the required concentrations (100% of aqueous extract) and allowed to stay soaked for 72 hours. After filtration using a clean and sterile cheese cloth, 100 ml of soap solution was incorporated as sticker.

Spray application of treatment types:

The field trials were conducted on eight-year old cashew plantation consisting of Brazilian large cashew biotype, the trial was carried out for three consecutive years. Carbendazim at 0.5g a.i/l, mancozeb 2.0g a.i/l and botanical leaf extracts: *C. odorata* at 80%, *C. papaya* at 10% and *A. conyzoides* at 80% were evaluated separately and integrated (fungicide and botanical) as protectant against pathogen on cashew inflorescences. Thirty-six (36) selected cashew stands comprising of twelve trees per block were divided into halves. Forty (40) inflorescences, all at pre-bloom stage of flower development were randomly selected, each half bearing twenty (20) inflorescences and tagged according to color code, prior to treatment application. The cashew field were layout in 6m x 6m tree distance, the untreated trees serve as control and the treatments and control were replicated three times for the specific treatment type.

A knapsack sprayer of 15 liters capacity with fine nozzles was used to spray the inflorescences at the periphery to completely cover the

panicles according to treatments. There were four applications of the treatments separately and integrated system² with some modifications. The treatments were applied at intervals of 15 days both in single treatments and the integrations throughout the period of the study.

Dieback evaluation parameters:

Cashew inflorescence dieback was identified on the expressions of symptoms: withering of petals and other parts of the flower followed by a progressive dieback of the small peduncles from the tips and downward to the main floral shoots (Annexes I and II). Therefore, disease incidence was determined as number of infected inflorescences out of the forty total number assessed per tree per treatment [2]. Record of disease incidence was taken at 21-day interval after spraying throughout out flowering/nut initiation period. The disease rating scale for inflorescence dieback of cashew was adopted [12] with some modifications as follows:

Disease

Rating	Inflorescence dieback percent infection scale
0	Inflorescence free from infection
1	<25% of inflorescence was infected with <i>L. theobromae</i>
2	26–50% of inflorescence was infected with <i>L. theobromae</i>
3	51–75% of inflorescence was infected with <i>L. theobromae</i>
4	>75% of inflorescence was infected with <i>L. theobromae</i>

Record of observations of the percent disease incidence, percent disease index (PDI)/severity and percent disease reduction (PDR) calculated as follows:

Percent Disease Incidence

$$= \frac{\text{Number of infected inflorescence}}{\text{Total number of inflorescence counted/assessed}} \times 100$$

Severity

$$= \frac{\text{Sum of Disease Rating}}{\text{Total inflorescence assessed} \times \text{Max. rating value}} \times 100$$

Percent Disease Reduction

$$= \frac{\text{PDI (Control)} - \text{PDI (Treatment)}}{\text{PDI (Control)}} \times 100$$

All data were statistically analyzed using analysis of variance (ANOVA) to determine the differences between treatments and means were separated using Duncan Multiple Range Test (DMRT) at 5% probability level.

3. Results and Discussion

The post treatment evaluation of the test fungicides and botanical extracts applied alone and integrated in field trial in 2012/2013 cashew season showed dieback incidence were significantly low in all treatments compare to the control and significant differences were also observed between single and integrated applications. The dieback incidence in Carbendazim, leaf extract of *C. odorata* and *A. conyzoides* – treated inflorescences were not significantly different but incidence was significantly higher in Mancozeb with leaf extract

of *C. papaya* – treated inflorescences among other treatments (Figure 1A). The evaluation of dieback in 2013/2014 cashew season showed significantly low incidence in Carbendazim-treated flowers and differed from other treatment types and control. However, percent dieback incidence was significantly higher in Mancozeb with *C. odorata* integration.

All treatment types were better than the control stands (Figure 1B). The degree of incidence of inflorescence dieback in 2014/2015 cashew season shows significant similarities in treated cashew stands except trees with integration of mancozeb with *C. odorata* which gave significantly higher dieback and this was similarly observed in the two previous cashew seasons. Low incidences of dieback diseases was recorded in the integrations of Carbendazim with plants' extracts and Mancozeb with *C. papaya* integration (Figure 1C).

The Figure 2 showed the severity record of inflorescence die-back in 2013 was significantly low when treated with *C. papaya*, Carbendazim with *C. odorata* integration and Carbendazim with *C. papaya* integration. Die-back severity recorded in integration of Mancozeb with *C. odorata* was significantly higher than other treatments and similar trend was recorded in integration of mancozeb with *A. conyzoides* in reducing the disease severity (Figure 2A).

The severity index of inflorescence dieback of cashew in 2013, showed the least mean severity of 1.47 as recorded in *C. papaya*-treated flowers with significant similarity with Carbendazim with *C. odorata* integration and Carbendazim with *C. papaya* integration. Severity index of this disease treated with *C. odorata*, *A. conyzoides*, mancozeb with *A. conyzoides* integration and Carbendazim with *A. conyzoides* are not significantly different. The dieback severity index was significantly higher in untreated control and differs from all treatment applications (Figure 2A). Variations in severity indexes were recorded in dieback disease on cashew in 2013/2014 season. The least dieback severity was recorded in Carbendazim-treated inflorescences and differs from other treatments which showed some similarity in severity index as recorded in cashew stands treated with *C. papaya*, integration of Carbendazim with *A. conyzoides* and Mancozeb (Figure 2B).

The severity of inflorescence dieback of treated cashew trees also varied in 2015 fruiting season and were significantly low compared to untreated control. Significant similarities were observed in the effect of treatment types on dieback severity after application except in cashew treated with Mancozeb single application and its integrations with *C. odorata* and *A. conyzoides* (Figure 2C).

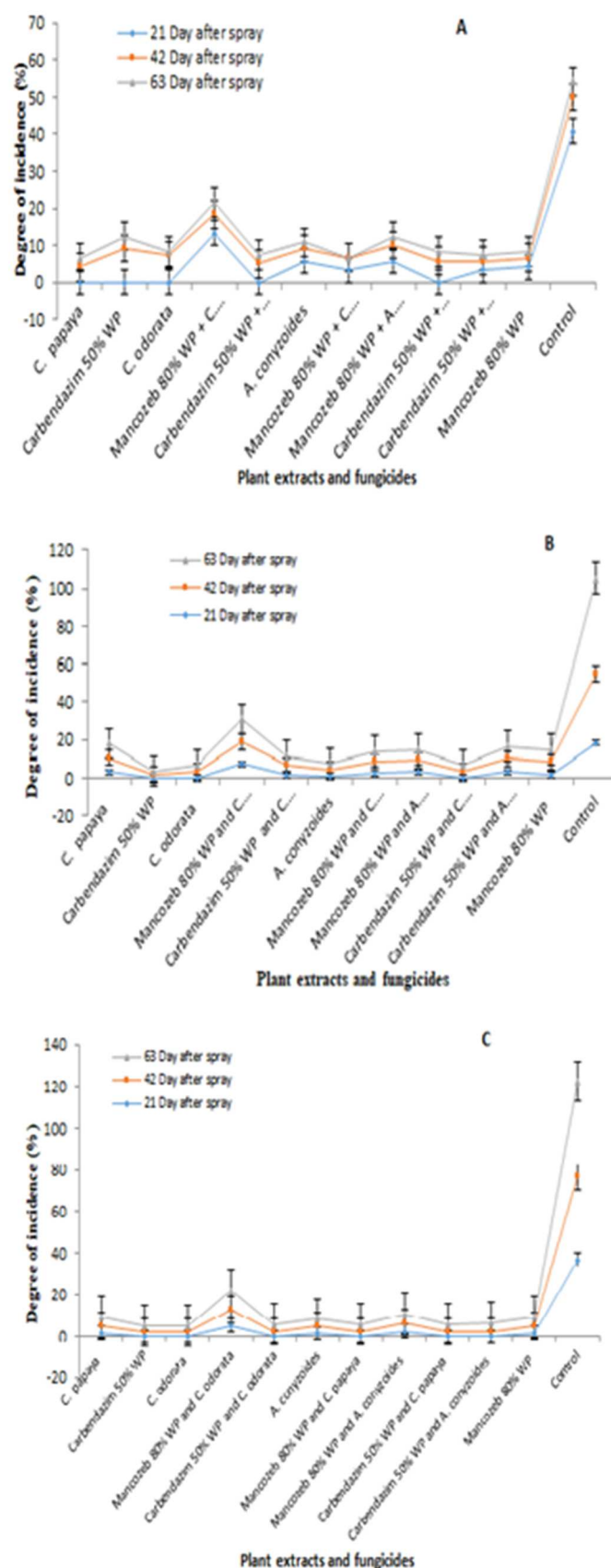
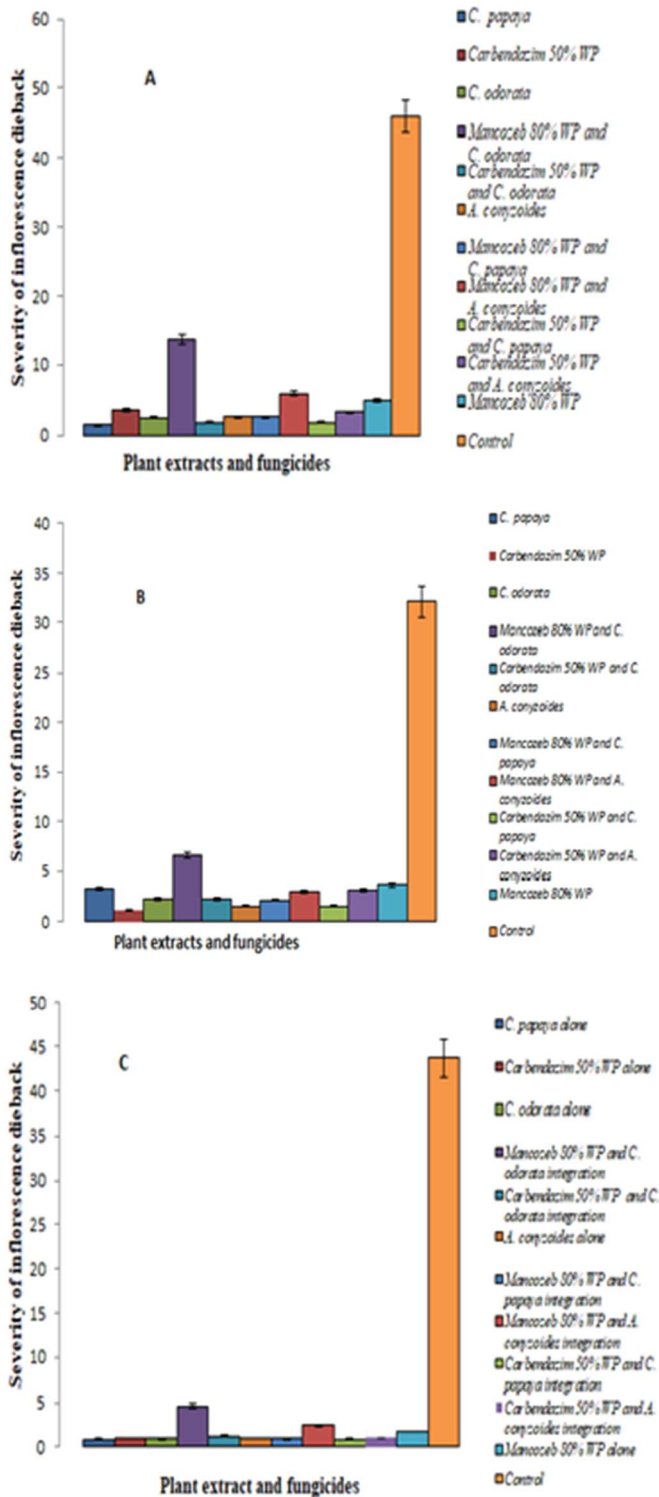


Figure 1

Effect of treatment types on inflorescence die-back incidence; A (2012/2013 season), B (2013/2014 season), C (2014/2015 season)

**Figure 2**

Effect of treatment types on dieback severity: A (2012/2013 season), B (2013/2014 season), C (2014/2015 season)

The severity index however varies significantly among single and integrated applications (Table 1). The effect of treatments on dieback disease was also measured by calculating percent diseases reduction on the floral parts. In the year under consideration, the highest of 96.79% reduction in dieback was recorded in *C. papaya*-treated inflorescences; Carbendazim with *C. papaya* integration gave 96.07% disease reduction and Carbendazim with *C. odorata* showed 95.89% dieback reduction (Table 1).

The assessment of effect of treatments types on crop yield showed significantly higher yield in inflorescences treated with integration of Mancozeb with *C. odorata*, carbendazim and mancozeb with *A. conyzoides* integration showing 93.22, 56.44 and 55.78 nuts. Some other treatment types that showed reduction in percent disease and severity had significant similarity in crop yield compared to untreated control (Table 1).

Record of evaluation of crop yield based on number of nuts was taken at interval of 21 days from last application. Figure 3 showed that number of cashew nut produced in Mancozeb with *C. odorata*-treated inflorescences was significantly higher (839) ($P = 0.05$) than yield in other treatments and control. Significant similarities were recorded in yields of *C. papaya*, carbendazim, *A. conyzoides* and integration of mancozeb with *A. conyzoides*, however differed significantly from other treatments and control. Least crop yield was recorded in flowers treated with integrations of *C. papaya* and the fungicides which showed significant similarity.

The effect of Carbendazim single application and its integration with *A. conyzoides* on dieback severity and nut production are significantly similar but differ significantly from other applications in nut production (Table 2).

Table 1

Effect of integrated system on disease severity index of inflorescence die-back of cashew (2012/2013 season)

Treatment	Severity index				Percent Disease Reduction (PDR) over Control	Number of Nut
	I	II	III	Mean		
<i>C. papaya</i>	0.00	1.71	2.71	1.47 ^d +0.79*	96.79	45.44 ^{ab} (409)***
Carbendazim 50% WP	0.00	4.59	6.25	3.61 ^{cd} +1.87**	92.12	56.44 ^a (508)
<i>C. odorata</i>	0.00	3.34	4.38	2.57 ^{cd} +1.32	94.45	34.11 ^b (307)
Mancozeb 80% WP & <i>C. odorata</i>	11.67	14.17	15.0	13.61 ^b +1.0	70.31	93.22 ^a (839)
Carbendazim 50% WP & <i>C. odorata</i>	0.00	2.5	3.13	1.88 ^d +0.96	95.89	29.67 ^b (267)
<i>A. conyzoides</i>	1.67	2.92	3.34	2.64 ^{cd} +0.50	94.24	43.44 ^{ab} (391)
Mancozeb 80% WP & <i>C. papaya</i>	1.88	2.92	3.13	2.64 ^{cd} +0.39	94.24	10.78 ^b (97)
Mancozeb 80% WP & <i>A. conyzoides</i>	4.59	6.05	6.88	5.84 ^c +0.67	87.26	55.78 ^a (502)
Carbendazim 50% WP & <i>C. papaya</i>	0.00	2.27	3.13	1.80 ^d +0.93	96.07	10.33 ^b (93)
Carbendazim 50% WP & <i>A. conyzoides</i>	2.50	3.54	3.96	3.33 ^{cd} +0.43	92.74	36.89 ^b (332)
Mancozeb 80% WP	3.75	5.00	5.63	4.79 ^{cd} +0.55	89.55	43.00 ^b (387)
Control	39.59	48.13	49.79	45.84 ^a +3.16	0.00	18.56 ^b (167)

*Standard Error of Mean: **Means followed by the same letter in each column are not statistically different (P = 0.05):

***Value in parenthesis is total nut set per treatment

Table 2

Effect of integrated system on disease severity index of inflorescence dieback of cashew (2013/2014 season)

Treatment	Severity				Percent Disease Reduction (PDR) over Control	Number of Nut
	I	II	III	Mean		
<i>C. papaya</i>	1.25	4.38	4.38	3.34 ^b +1.04*	89.59	17.00 ^{ab} (153)***
Carbendazim 50% WP	0.00	1.67	1.67	1.11 ^b +0.56**	96.54	54.00 ^a (486)
<i>C. odorata</i>	0.00	3.33	3.33	2.22 ^b +1.11	93.08	29.33 ^{ab} (264)
Mancozeb 80% WP & <i>C. odorata</i>	4.38	7.71	7.71	6.60 ^b +1.12	79.43	32.22 ^{ab} (290)
Carbendazim 50% WP & <i>C. odorata</i>	0.63	3.13	3.13	2.29 ^b +0.83	92.86	22.56 ^{ab} (205)
<i>A. conyzoides</i>	0.42	2.08	2.08	1.53 ^b +0.55	95.23	28.22 ^{ab} (254)
Mancozeb 80% WP & <i>C. papaya</i>	0.63	2.92	2.92	2.16 ^b +0.76	93.27	16.33 ^{ab} (147)
Mancozeb 80% WP & <i>A. conyzoides</i>	1.88	3.54	3.54	2.99 ^b +0.55	90.68	11.89 ^b (117)
Carbendazim 50% WP & <i>C. papaya</i>	0.00	2.29	2.29	1.53 ^b +0.76	95.23	34.56 ^{ab} (311)
Carbendazim 50% WP & <i>A. conyzoides</i>	1.46	3.96	3.96	3.13 ^b +0.83	90.25	52.89 ^a (396)
Mancozeb 80% WP	0.63	5.21	5.21	3.68 ^b +1.53	88.53	27.67 ^{ab} (249)
Control	15.42	33.75	47.09	32.09 ^a +9.18	0.00	11.78 ^b (106)

*Standard Error of Mean: **Means followed by the same letter in each column are not statistically different (P = 0.05):

***Values in parenthesis are total nut per treatment

Figure 3 showed that untreated control recorded the least of 106 nut produced and differ significantly with other treatment except integration of mancozeb with *A. conyzoides*. Highest of 486 nuts was obtained when Carbendazim was applied, differs from nuts obtained from other treatment types and nut yield obtained from cashew stands treated with *C. odorata*, *A. conyzoides* and Mancozeb were not significantly different. A similar result was also obtained with *C. papaya* single application and integration mancozeb, while nut production varies with other treatment types (Figure 3B). Mancozeb with *C. odorata* integration recorded the least percent disease reduction (89.46%) while other treatment types had higher reduction percentage of dieback disease. The nut production in 2015 fruiting season varied with treatment types, best number of nut (873) was recorded in Mancozeb with *C. odorata*-treated stands,

with similarity in the yield record of 2012/2013 cashew season. The nut yield of cashew treated with *C. papaya*, integrations of Mancozeb with *A. conyzoides* and Carbendazim with *A. conyzoides* were not different. Significant similarity was also recorded in the nut production of cashew stands treated with *C. odorata* and integration Carbendazim with *C. papaya* (Figure 3C).

In the table 2, the least severity (I,II) of inflorescence dieback in 2013/2014 was recorded in Carbendazim-treated cashew stands; severity index of integration of Carbendazim with *C. papaya* and *A. conyzoides*-treated stands was 1.53. Cashew treated with and integration of Mancozeb with *C. odorata* had the highest severity of 6.60 but not significantly different from other treatments. The second-year field trial showed that Carbendazim-treated cashew gave highest percent disease reduction (96.54%), followed by

95.23% recorded in both *A. conyzoides* and integration of Carbendazim with *C. papaya*-treated stands. But cashew stands treated with Mancozeb with *C. odorata* recorded least percent reduction of dieback disease (Table 2).

Table 3 shows the result after third year of application of treatment types in the management of inflorescence dieback of cashew. The assessment of disease severity this season (2014/2015) indicates highest dieback severity of 43.65 in untreated control and the least severity of 0.90 was recorded in *C. papaya*-treated cashew stands with significant similarity with Carbendazim, *C. odorata*, integration of Carbendazim with botanical extracts, *A. conyzoides*, integration of Mancozeb with *C. papaya* (Table 3).

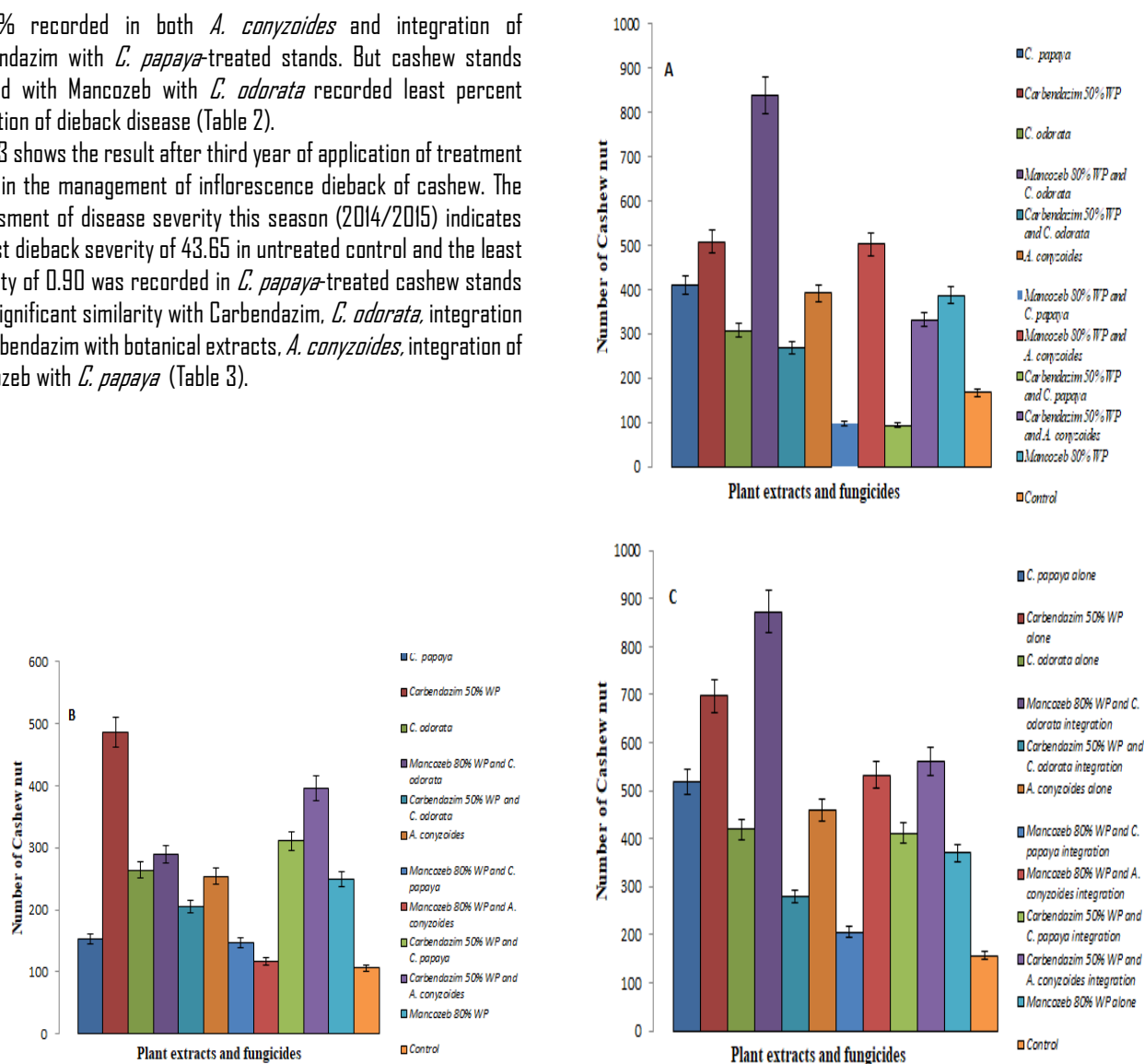


Figure 3

Effect of treatment types on total yield of cashew : A (2013 season), B (2014 season), C (2015 season)

Table 3

Effect of Integrated Management on disease severity index of Inflorescence dieback of Cashew (2014/2015 season)

Treatment	Severity				Percent Disease Reduction (PDR) over Control	Number of Nut
	I	II	III	Mean		
<i>C. papaya</i>	0.42	1.04	1.25	0.90 ^a +0.25*	97.94	57.56 ^{ab} (518)***
Carbendazim 50% WP	0.00	1.05	1.88	.98 ^c +0.54**	97.75	79.56 ^{ab} (697)
<i>C. odorata</i>	0.00	1.19	1.67	0.95 ^c +0.49	97.82	46.56 ^{ab} (419)
Mancozeb 80% WP & <i>C. odorata</i>	3.81	4.76	5.24	4.60 ^b +0.42	89.46	97.00 ^a (873)
Carbendazim 50% WP & <i>C. odorata</i>	0.00	1.43	2.38	1.27 ^c +0.69	97.09	31.00 ^{ab} (279)
<i>A. conyzoides</i>	0.71	1.19	1.19	1.03 ^c +0.16	97.64	51.22 ^{ab} (461)
Mancozeb 80% WP & <i>C. papaya</i>	0.00	1.19	1.67	0.95 ^c +0.49	97.82	22.89 ^b (206)
Mancozeb 80% WP & <i>A. conyzoides</i>	1.67	2.86	2.86	2.46 ^{bc} +0.39	94.36	59.22 ^{ab} (533)
Carbendazim 50% WP & <i>C. papaya</i>	0.00	1.19	1.43	0.87 ^c +0.44	98.01	45.77 ^{ab} (412)
Carbendazim 50% WP & <i>A. conyzoides</i>	0.00	1.19	1.91	1.03 ^c +0.56	97.64	62.33 ^{ab} (561)
Mancozeb 80% WP	0.95	1.91	2.38	1.75 ^{bc} +0.42	95.99	41.11 ^{ab} (370)
Control	39.52	42.14	49.29	43.65 ^a +2.92	0.00	17.45 ^b (157)

*Standard Error of Mean: **Means followed by the same letter in each column are not statistically different (P = 0.05):

***Values in parenthesis are total nut per treatment

The single and integrated applications of treatment types reduce the severity of inflorescence dieback disease throughout the field trial on cashew trees.

The Figure 4 showed that cashew trees treated with integration of mancozeb with *C. odorata* recorded the best nut yield in 2013 and 2015 seasons and carbendazim-treated cashew stands gave the best nut yield in 2014 season. *Ageratum conyzoides* and *C. papaya* single applications recorded a higher cashew nut yields compared to other plants' extracts, however integrated applications of treatment types produced better cashew nut yield than single applications of either extracts or active ingredients with the exception of carbendazim.

However, yield in 2015 was higher on the average due to absence of rain in December 2014 and January 2015 as the rain usually caused flower abortion on some inflorescences which reduced nut initiation and subsequent yield.

The correlation analysis of dieback severity and yield of cashew showed a negative linear relationship in cashew trees treated with

integrations of Carbendazim with *C. odorata*, *C. papaya* and *A. conyzoides*, Mancozeb and its integration with *C. papaya* and *C. odorata* in 2014 fruiting season. The correlation coefficient ($r = -0.961$) indicates a strong correlation between dieback severity and yield of cashew treated with Carbendazim, correlation coefficient ($r = -0.680$) recorded in integration of Carbendazim with *C. papaya* but the weakest correlation coefficient ($r = -0.091$) was recorded integration of Mancozeb with *C. papaya*-treated cashew in 2014 fruiting season. In 2015 fruiting season, Carbendazim, *C. odorata*, integration of Carbendazim with *A. conyzoides* and mancozeb recorded a correlation coefficient of $r = -0.933$, -0.931 , -0.636 and -0.908 respectively, but a weak correlation coefficient $r = -0.124$ was recorded in untreated control. Although no single treatment type showed negative linear relationship in 2013 fruiting season but the correlation effect of over all treatment types in the same year recorded negative linear relationship between dieback severity and yield of cashew.

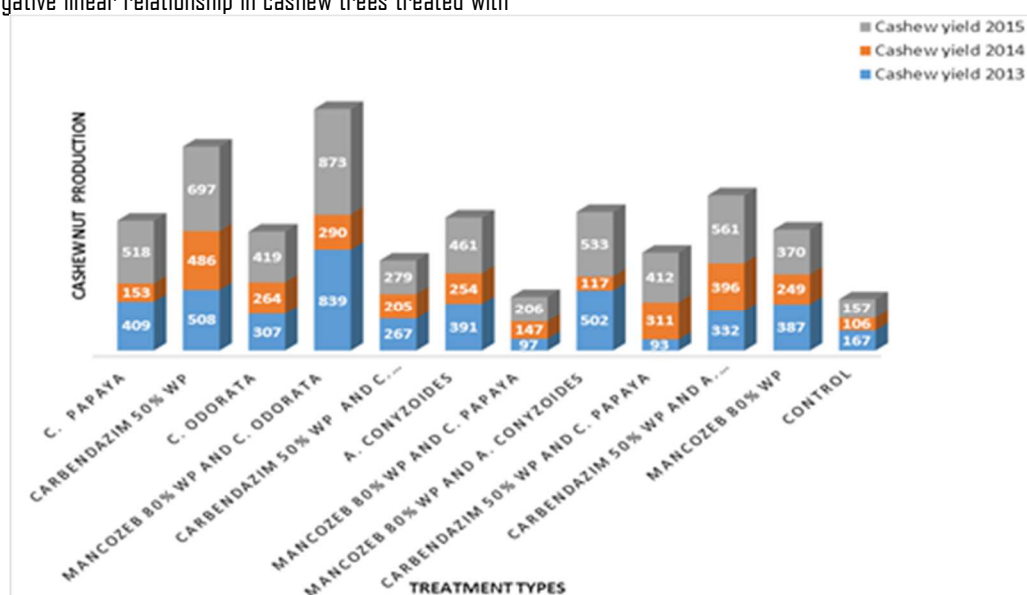


Figure 4
Potentials of treatment types on improvement of cashew yield

Discussion

This study explores the efficacy of *A. conyzoides*, *C. papaya* and *C. odorata* as promising plant-based antifungi agent against *L. theobromae* of cashew in Nigeria and their combination into a disease management strategy of inflorescence dieback of cashew. The extended period during which the inflorescence is susceptible to disease because of irregular flowering would necessitate multiple applications of the treatments. Therefore, the frequency of treatment application in this study corroborates the 3-4 sprays during the flowering season as recommended reported in earlier findings [2].

Classical biological control approach can offer promising and provide ecologically sound control of cashew diseases. The antifungal activity of leaf extract of *C. odorata* against *L. theobromae* pathogen of cashew inflorescence dieback was very significant [13]. Also Ilondu [14] and Adjei [15] reported the fungicidal effect of *C. papaya* and *C. odorata* against *B. theobromae* a synonyms of *L. theobromae*. Another possible area in management of cashew

dieback is the integrations of fungicides and botanical extracts. This application is however based on the existing microclimatic record of the plantation which is a condition to ensure optimum developmental activity of cashew. Dependence on agrochemicals is minimized by integrated approaches which result in superior disease suppression and reducing yield loss.

Comparison of the incidence of inflorescence dieback in the field trials showed the degree of disease incidence varies from one year to another. There was reduction in incidence in year two and three with regard to some of the various treatments with few exceptions of equity or higher incidence in some treatments. However, consistent decline in dieback incidence was recorded in cashew stands treated with *C. odorata*, Mancozeb with *C. odorata*, Carbendazim with *C. odorata*, mancozeb with *C. papaya*, mancozeb with *A. conyzoides*, Carbendazim with *C. papaya*, Carbendazim with *A. conyzoides* and Mancozeb across the three years cashew seasons. The disease incidences were however highest in untreated controls, but dieback incidence was significantly lower in all

treatments in 2015 showing the efficacy of the treatments applications both singular and integrated system.

The highest disease severity was observed in the year one of field trial, with exception of *C. papaya* application and the severity progressively decreased to year three. Consistent declines in dieback severity were observed in treatment typee, however, *C. papaya* and Carbendazim with *C. odorata* showed some variations. The least severity was recorded cashew stands treated with Carbendazim with *C. papaya* in 2015 while highest severity was recorded in Mancozeb with *C. odorata* in 2013. The severity of cashew dieback was consistently high in untreated control however exception of high dieback severity was recorded in 2013 with Mancozeb and *C. odorata* integration.

Many treatments recorded similarity in cashew nut yield, trees treated with Carbendazim, Mancozeb with *A. conyzoides* integration in 2013, had similar yield with Carbendazim-treated stands in 2014. In 2015, *Carica papaya*, integrations of mancozeb with *A. conyzoides* and Carbendazim with *A. conyzoides* recorded similarity in nut yield. *Carica papaya*, *A. conyzoides*, Mancozeb in 2013, Carbendazim with *A. conyzoides* integration in 2014, *C. odorata*, Carbendazim with *C. papaya* and Mancozeb-treated stands in 2015 had similar nut yield. The nut yield obtained from application of *C. odorata*, Carbendazim with *A. conyzoides* in 2013, mancozeb with *C. odorata*, Carbendazim with *C. papaya* in 2014 and Carbendazim with *C. odorata* integration in 2015 also recorded similar yield of cashew nut.

Treatment effects on cashew yield vary from one season to another. Higher yield was recorded in in 2013 season compare to yield of 2014 with few exceptions. Also nut yield in 2013 was generally better across treatment types except for few cases observed in integration of Carbendazim with *C. papaya* and with *A. conyzoides* whose yield was better in 2014 with 311 nuts and 396 nuts compare to 2013 with 93 nuts and 332 nuts respectively. Differences observed in the cashew nut yield in the 2013 and 2014 fruiting seasons in relation to the treatments applied. The treatment except integration of Mancozeb with *C. papaya* on one hand and Carbendazim with *C. papaya* on the other hand produced more than 100% extra nuts compared to control in 2013 and increments in nut yield to 502% in integration of mancozeb with *C. odorata*.

Results obtained showed lower yield in 2014 season which could be linked to the prevailing weather situation in the study location. Mean temperature fell below 20°C and incidences of rain fall during flower blooming. Increment in yield was recorded in *C. papaya*, integrations of mancozeb with *C. papaya* and *A. conyzoides*, and carbendazim with *C. odorata*. The treatment types had varied effect on yield of cashew nut, carbendazim had 458% increment and integration of *C. odorata* with *A. conyzoides* showed 239% yield increment over control in 2014 season. Carbendazim, its integration with *A. conyzoides*, Mancozeb and its integration with *C. odorata* gave higher cashew nut yield in 2013 and 2014 seasons. However, some other treatments also gave good nut yield compared with the control in both seasons. Differences were not observed in the nut yield in cashew stands treated with Carbendazim, integration of Mancozeb with *A. conyzoides* in 2013 and Carbendazim in 2014. Also nut yield in *C. papaya*, *A. conyzoides*, Mancozeb-treated trees in 2013 and Carbendazim with *C. papaya*-treated stands in 2014 were similar.

Yields records in cashew tree treated with Carbendazim with *C. odorata* in 2013, *C. odorata*, *A. conyzoides* and Mancozeb in 2014 applications were also similar.

The weather situation have some effect on cashew nut yield vis-à-vis presence or absence of rainfall, prolonged harmmatan condition as it relate with flower initiation and blooming which were needful for good fruiting of the tree. The season and the area of production did affect significantly appearance of flowers, fruits and also nuts and apples production. The agro-climatic stress index, amount of rainfall and the number of rainy days were main factors determining cashew trees' production [16]. Any incidence of rainfall during cashew flowering period do hamper flower development, nut initiation and yield eventually, as this caused flower abortion and reduced pollinators visit to the flowers.

More importantly, best quality cashew is produced during dry periods as frequent rainfall during flowering and fruit development may result in severe fruit diseases and damages problem.

Conclusion

The study showed the efficacy of integrated system in the management of inflorescence dieback of cashew caused by *L. theobromae*, Carbendazim, Mancozeb, *A. conyzoides*, *C. papaya* and *C. odorata* were effective *in-vivo*. The most effective integrated strategy that improve yield were Mancozeb + *C. odorata*, Carbendazim + *A. conyzoides*, Carbendazim + *C. papaya* and Mancozeb + *A. conyzoides* combinations. Treatments that showed similar effect on yield were Carbendazim, mancozeb + *A. conyzoides* (2013), Carbendazim (2014), *C. papaya*, Mancozeb + *A. conyzoides* and Carbendazim + *A. conyzoides* (2015), *C. papaya*, *A. conyzoides*, Mancozeb (2013), Carbendazim + *A. conyzoides* (2014), *C. odorata*, Carbendazim + *C. papaya* and Mancozeb (2015) have similarity in yield. Also are the yield records when treated with *C. odorata*, Carbendazim + *A. conyzoides* in 2013, Mancozeb + *C. odorata*, Carbendazim + *C. papaya* in 2014 and Carbendazim + *C. odorata* in 2015. The simplicity of integrated approach should ease the level of adoption by cashew farmers.

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