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Citec Soap: A New Additive for *Cassia nigricans* and *Capsicum annum* Aqueous Extracts to Control White Flies (*Bemisia tabaci* (Homoptera, Aleyrodidae) and *Helicoverpa armigera* (Lepidoptera, Noctuidae) on Tomato in Burkina Faso

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***Abstract* – A pre diffusion study of *Cassia nigricans* and *Capsicum annuum* aqueous extracts with CITEC factory soap and adhesol as additives was conducted with farmers in four locations (Valley kou, Kongoussi, Yako and Diébougou) against white flies (*B. tabaci*) and army worm (*H. armigera*) which cause huge tomato yield losses to Burkina Faso' farmers. The number of white flies was counted using transparent cylindrical cages covering 20 tomato plants with white flies on four rows of the useful plot. The infestation rate of *H.armigera* on tomato fruits was evaluated on all plants of the useful plot at harvesting. The biological efficiency coefficients of different formulations were evaluated using Afanaseeva *and al*. (1983) formula. On *B. tabaci*, the biological efficiency coefficients of *C. nigricans* (250l/ha) formulated with CITEC soap (52g /16l) varied from 35, 23 to 79, 38 against 30, 48 to 67, 15 on *C.nigricans* (250l /ha) formulated with the adhesol (30cc / hl). The biological efficiency coefficients of *C. annuum* (250l/ha) formulated with CITEC soap (52g /16l) varied from 35, 28 to 74,11while *C.annum* formulation (250l /ha) formulated with the adhesol (30cc / hl) varied from 28, 14 to 73, 73. Extracts of C. Annum (250l / ha) and *C. nigricans* (250l / ha) formulated with CITEC soap powder (52g / 16 l) provided reductions of *H.armigera* respectively of 57, 23% and 52, 43% in comparison with untreated control. These factors have allowed the aqueous extracts formulations with CITEC soap to show equivalent performance to the formulation with adhesol and to deltamethrin. Also, it shows that CITEC soap can be an alternative to adhesol in the formulations of aqueous plant extracts used as natural insecticides while preserving consumer's health and the environment.**

***Keywords* – *Bemisia tabaci, Capsicum Annum, Cassia Nigricans, Helicoverpa armigera*.**

I. INTRODUCTION

The agricultural sector remains a critical component for the economic development of West African countries. This is primarily because of its strong contribution to the people alimentation, creation of employment, income and overall wealth. Agricultural production also plays an important role in enhancing and maintaining the export balance for many countries in the region. Among the agricultural sectors, the horticultural sector occupies a significant space.

In Senegal, for example, fruits and vegetables are among the fastest growing industries according to the number of farmers, the density of crops and regions involved [1]. This is similar in Mali, where the vegetable production is spread over the territory [2]. In Burkina Faso, the agricultural production depends on both male and female farmers (men 74, 4%, women 25, 6%). The horticultural sector is generating substantial foreign exchange to the national economy. Between 1996 and 2002, its role in the economic growth passed from 8 to 40% and 10 to 41%, respectively. At the same time, the increase in the agricultural output surpassed from 11 to 99% and 16 to 50%, respectively. In general, the contribution to the overall growth of the economy has increased from 36% in 1996 to 59% in 2002. Vegetable production at the end of the 2004-2005 season was estimated at 166,147 tonnes, nearly 156,636 tonnes declared sold [3]. According to the same source, tomato is still the most profitable vegetable. Indeed, the evaluation of benefit margins per vegetable production shows that tomato yielded 5.5 billion CFA francs, followed by onion with 4.5 billion CFA francs.

Despite the significant production potential that exists for agricultural crops (land, water, plant etc.), several major constraints handicap the development of horticultural crops including vegetables. Thus, tomato's production constraints are mainly related to packaging, storage and transport. In the area of production, substantial damage caused by pests including whitefly (*Bemisia tabaci*), caterpillars (*Helicoverpa armigera*) is highly significant. The whitefly is considered as one of the pests cause the most damage in agriculture. It is responsible for significant market loss and low prices especially for tomato [4, 5]. Many studies on the population dynamics [6, 7] and the distribution of whitefly [5, 8] have been reported. Several control methods have been proposed to overcome this insect pest on tomato, which include the use of mineral nutrition with potassium to influence the resistance of the plant [4] and biological control by parasitoids [9, 5]. Such studies have also been done on *H. armigera* on tomato [10]. A number of studies on rational management against the pest damage thresholds and economic impact by *H. armigera* have been reported [11-13]. However, chemical control is the most practiced method to manage white flies. The problem is widespread that these pests also attack cotton crop. By the end of cotton season, some farmers who practice tomatoe production tend to use the same chemical molecules in vegetables by increasing the risk of toxicity and environmental pollution. Farmers often do not know the

actual size of their plots and are therefore unable to define exactly the amount of insecticide required despite the instructions provided by the pesticide companies. Generally, to measure the amount of pesticide, the company provides a plastic cap as a measure of the quantity of formulated pesticide to transfer to the spraying apparatus. Moreover, there is a risk for pest to become resistant to the insecticides of the chemical family of pyrethrenoids [14] organophosphorus and neonicotinoids [15, 16]. In order to reduce these risks, studies have been conducted to find alternatives to synthetic insecticides. For example, the use of parasite, *Macrolophus caliginosus,* as a biological control against whitefly [17-20] and natural substances with insecticidal properties [21] are getting popular to manage white fly. The insecticidal activity of *Cassia nigricans* has been reported and its activity was attributed to three (3) anthraquinones and one flavonoid present in it [22]. The use of this extract (showed at Burkina Faso Forum for Scientific Research and Technological Innovations, in 2008) by the company GRA ZEMS- Taaba of Ziniaré city, faced formulation challenges due to the lack of adequate adjuvant. Similar situation has been noticed with the aqueous extracts of pepper, which shows insecticidal activity against green beans pest whitefly and thrips [23]. Therefore, this study was undertaken to find an addidive for plant natural extracts of *C. annuum* and *C. nigricans* that show promising insecticidal activity by ensuring leaching reduction and improved efficiency over its existing formulations as an integrative approach to manage tomato pests.

II. Materials and Methods

A. Materials

Pre diffusion trials were implanted in four locations (Diébougou, Kongoussi, Kou Valley, Yako). Diebougou is located at 138 km from Bobo Dioulasso and Kou Valley at 25 km from Bobo Dioulasso in pre-Guinean area. Kongoussi and Yako at 471 km and at 380 km respectively from Bobo Dioulasso are located in the Sudan area. The soils at these locations are ferruginous except those at Kou Valley (sandy loam). The climate is Sudano-Sahelian. The plant material used in the study, tomato variety Petomech, is susceptible to whitefly (*B. tabaci*) and cotton bollworm (*H.armigera*). The cultivation methods consisted of plowing by animal traction followed by manual harrowing except at KouValley where these activities were carried out with a tractor. The nurseries were treated with Tropizeb (Mancozeb) and Carbodan (carbofuran5G) to protect against soil diseases, soil insect fauna and nematodes. NPK fertilizer (15-15-15) was applied at the rate of 200kg / ha during the transplanting, 30 day after; and 100 kg of urea 60 days after transplanting. The tropizeb (Mancozeb) was applied every 10 days in order to protect against diseases and 20 kg/ ha of Furadan (Carbofuran5G) during the transplanting against nematodes. Weeds were removed manually on demand and irrigated when necessary. The experimental design was a factorial experiment with 2 factors (extracts and additives) with additional controls in a randomized bloc design in 4 replications. The treatments were: Untreated plot (control); Decis (deltamethin) 1l / ha; *C. nigricans* (250l / ha) + adhesol (30 cm^3/100 liters of spray); *C. nigricans* (250l / ha) + CITEC soap (52 g / 16 liters / unit); *C. annum* (250l / ha) + adhesol (30 cm^3/100 liters of spray); *C. annum* (250l / ha) + CITEC soap (52g / 16 liters / unit). Each location (Kongoussi, Diébougou, kouValley, and Yako) was considered as a replication. The sizes of the experimental plot were 8m x 4m = 32m^2. The size of the useful plot was, 7,60m x 3.60 m = 24, 32m^2. The number of rows in the elementary plot was 6 and the number of rows in the useful plot, 4.

B. Methods

After applying natural insecticides and Decis, the phytotoxicity on tomatoes was evaluated by a visual rating scale from 0 to 10 (Method of Biological Testing Commission, European Union). The biological efficiency of the adjuvants associated with the various extracts against *B. tabaci* was evaluated using transparent cylindrical cages including 20 tomato plants, diagonally, on 4 lines of the experimental unit after white flies' infestations and after the spray every 7-10 days. On the same tomato plants, the number of *H. armigera* larvaes in tomato fruits was counted. The biological efficiency coefficients were evaluated using the following formula from [24].

$$c = 100 \times \left(\frac{A-B}{a} - \frac{a-b}{a} \right)$$

Where,

C = Biological effectiveness coefficient.

A – Number of insects before application of extracts on the treated plot.

B – Number of insects after application of extracts on the treated plot.

a – Number of insects before application of extracts on the untreated control plot.

b – Number of insects on the untreated control plot after application of extracts on the treated plots.

The yield components were estimated after counting tomato fruits and weighing it.

An analysis of variance of data [25] was computed and means separations carried out using Newman-keuls test at 5% level using GENSTAT DISCOVERY.4 software. The correlations between the studied factors were computed, using ORIGIN 3.0 software.

III. Results

A. Effects of C. annuum and C. nigricans Aqueous Extracts Formulated with Additives on Tomato Establishment after Planting.

During the tomato establishment, phenological stages and after spraying plant extracts and Decis, there were no cases of phytotoxicity observed on tomato.

B. Effects of C. annuum and C. nigricans Aqueous Extracts Formulated with Additives on the Whitefly (B. tabaci) Population Density.

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Before the spraying period of aqueous extracts formulated with different additives and Decis, the level of whitefly infestations in the plots was characterized by an average (2, 61 flies / plant), a non-significant decrease compared to the untreated control (Table 1).

At the 60th day after application, the average effect of natural insecticides and Decis (1, 81 flies / plant) on the whitefly population showed respectively significant reduction from 40, 46% and 49, 30% compared to the untreated plot. Between natural extracts formulated with additives and Decis, there was no significant difference. At the 90th day after application, the average effect of pesticides (1, 32 flies / plant) showed a reduction from 40, 00% and 34, 33% compared to the untreated plot. Between the aqueous extracts formulated with additives and Decis there were no significant difference.

C. Biological Coefficients Efficiency of Different Plant Aqueous Extracts, formulated with Additives, on B. tabaci.

The biological efficiency coefficients of Decis on *B. tabaci* were evaluated by [24] formula and it ranged between 30 and 74 (Table 2). Those formulated with the chili extract and adhesol ranged between 14 and 73 while chili and CITEC soap ranged between 28 and 74. The coefficients of *C. nigricans* formulated with adhesol varied from 30 to 67 and those of *C. nigricans* with CITEC soap from 23 to 79. The best coefficient efficiencies obtained were for aqueous plant extracts formulated with CITEC soap as additive.

Table I: Effects of C.annuum and C.nigricans aqueous extracts formulated with additives on B. tabaci (average / plant).

Treatments		Observation periods (DAA= Day After Application)					
		0		60		90	
Extract	**Additives**	Without trans.	**After $\sqrt{x+1}$**	Without trans.	**After $\sqrt{x+1}$**	Without.trans.	**After $\sqrt{x+1}$**
Untreated control		7,47	**2,91ab**	11,74	**3,57a**	3,04	**2,01 b**
		7,47	**2,91ab**	11,74	**3,57a**	3,04	**2,01 b**
		7,47	**2,91ab**	11,74	**3,57a**	3,04	**2,01 b**
Decis 1l / ha		8,76	**2,79abc**	1,58	**1,90 c**	0,95	**1,37 c**
		8,76	**2,79 abc**	1,58	**1,90 c**	0,95	**1,37 c**
		8,76	**2,79abc**	1,58	**1,90 c**	0,95	**1,37 c**
C. annum (250l / ha)	Untreated Control	9,35	**2,99a**	8,64	**3,04 b**	4,11	**2,20a**
	Adhesol (30cc / hl)	6,64	**2,48 d**	1,24	**1,76 c**	1,05	**1,32 c**
	Citec Soap (52g / 16l)	6,34	**2,50 d**	1,16	**1,74 c**	0,55	**1, 23 c**
C. nigricans (250l/ha)	Untreated Control	9,35	**2,99a**	8,64	**3,04 b**	4,11	**2,20a**
	Adhesol (30cc / hl)	5,86	**2,44 e**	1,48	**1,87 c**	0,79	**1,32 c**
	Citec Soap (52g / 16l)	7,91	**2,72abcd**	1,03	**1,66 c**	0,69	**1,28 c**
Mean		**2,77**		**2,46**		**1,64**	
Extract effects		***		***		***	
Additives effects		***		***		***	
Interaction		***		***		***	
CV (%)		**7,20**		**8,80**		**7,00**	
LSD (05)		**0,29**		**0,31**		**0,16**	

N.B: Means followed by the same letter within the column are not significantly different at $p < 0,05$ and the sigle *** means high significant difference.

Table II: Efficiency coefficients of plant extracts formulated with additives against white flies

Treatments		**Observation periods (DAA=Day After Application)**		
Extract	**Additive**	**0**	**60**	**90**
Untreated control		-	-	-
Decis 1l / ha		-	74,36	33,30
C. annum (250l / ha)	Adhesol (30cc / hl)	-	73,73	28,14
	Citec Soap (52g / 16l)	-	74,11	35,28
C. nigricans (250l / ha)	Adhesol (30cc / hl)	-	67,15	30,48
	Citec Soap (52g / 16l)	-	79,38	35,23

D. Effects of Plant Aqueous Extracts, formulated with Additives, on H. armigera.

As shown by analysis of variance, the formulations tested influenced the accumulation of infestations due to cotton bollworm, *H. armigera* (Table 3). The average effect of the products tested (from 9, 40 larvae / tomato) showed significant reduction of infective larvae from 53, 47% and from 55, 72% (Decis and plant extracts) when compared to the untreated control. Between aqueous extracts formulated with different additives and the control

insecticide Decis, there was no significant difference in activity. However, a downward trend in the number of larvae was observed for *C. annum* (yellow pepper extract) formulated with CITEC soap and adhesol.

E. Effects of Plant Aqueous Extracts formulated with Additives on Tomato Yield Components.

Based on the number of harvested tomatoes criteria, the average effect of insecticides (from 287873, 29 tomato's fruits / ha) showed an increase of 207, 59% or 243, 09% of tomato fruits compared to the untreated control. Between the aqueous extracts formulated with additives, there was no significant difference (Table 4). Based on yield criteria, the average effect of insecticides (22174, 71 kg / ha) indicated an increase of 211, 31% or 217, 19% compared to the untreated control. Among treatments, Decis and pepper (*C. annum*) formulated with CITEC soap, adhesol and *C. nigricans* extract formulated with adhesol, there were no significant difference. The extracts mentioned above gave yield increases of 192, 54% to 198, 38% compared to the untreated control. The best yield between the plant aqueous extracts was obtained for *C. annuum* formulated with CITEC soap.

Table III: Effects of C.annuum and C.nigricans aqueous extracts formulated with additives on tomato H. armigera (%).

Treatments		Without transf.	**After angle-arcsin$\sqrt{p}$**
Extract	**Additive**		
Untreated control		11,90	**20,20 ab**
		11,90	**20,20 ab**
		11,90	**20,20 ab**
Decis 1l / ha		2,94	**9,68 cd**
		2,94	**9,68 cd**
		2,94	**9,68 cd**
C. annum (250l / ha)	Untreated Control	14,94	**21,23 a**
	Adhesol (30cc / hl)	2,26	**8,43 d**
	Citec Soap (52g / 16l)	2,60	**9,08 cd**
C. nigricans (250l / ha)	Untreated Control	14,94	**21,23 a**
	Adhesol (30cc / hl)	2,89	**9,17 cd**
	Citec Soap (52g / 16l)	3,69	**10,10 c**
Mean		**14,17**	
Extract effects		***	
Additives effects		***	
Interaction		***	
CV (%)		**5,30**	
LSD (05)		**1,07**	

Table IV: Effect of aqueous extracts formulated with adjuvants on tomato's yield components.

Treatments		**Quantity of tomatoes fruits (average /ha)**	**Yield (kg/ha)**
Extracts	**Additives**		
Untreated control		118421,00 e	10210,00 f
		118421,00 e	10210,00 f
		118421,00 e	10210,00 f
Decis			
		321238,00 a	23473,00 a
		321238,00 a	23473,00 a
Capsicum annum	Untreated Control	321238,00 a	23473,00 a
	Adhesol (30cc/hl)		
	Citec Soap (52g/16l)	138672,00 e	
Cassia nigricans	Untreated Control	292249,00 ab	10494,00 f
	Adhesol (30cc/hl)	236123,00 d	21596,00 bc
	Citec soap (52g/16l)		22185,00 ab
		138672,00 e	10494,00 f
		286904,00 abc	20818,00 bcd
		236123,00 cd	20205,00 cde
Mean		221071,00	19 092,00
Extract effects		***	***
Additives effects		***	***
Interaction		***	***
CV (%)		16,10	7,20
LSD (05)		52656,20	1773,10

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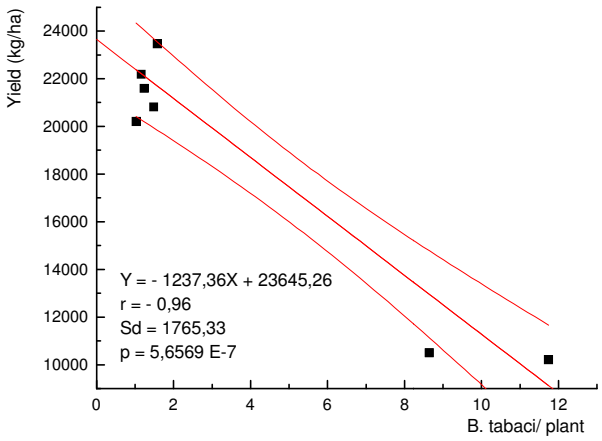
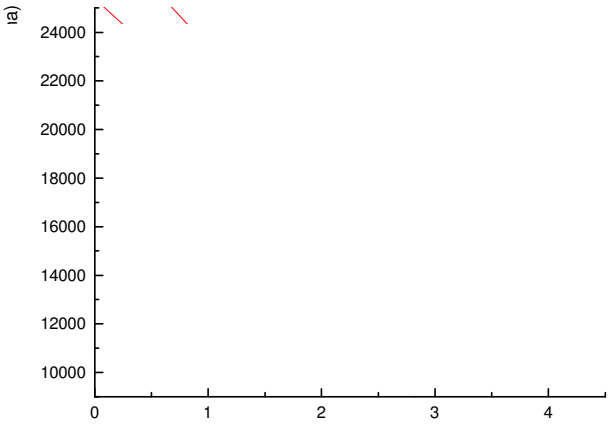
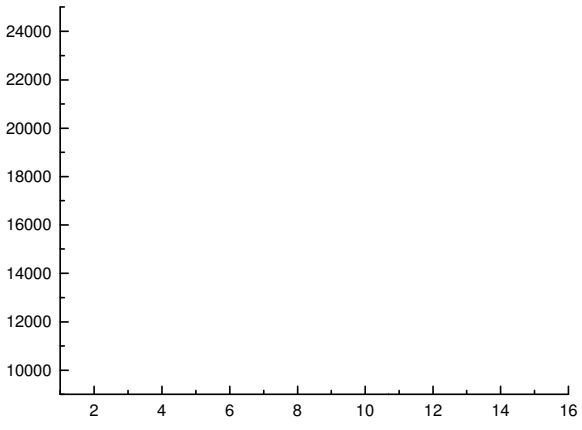


Fig 1: correlation between the density of B. tabaci at 60th day after application and tomato's yield.





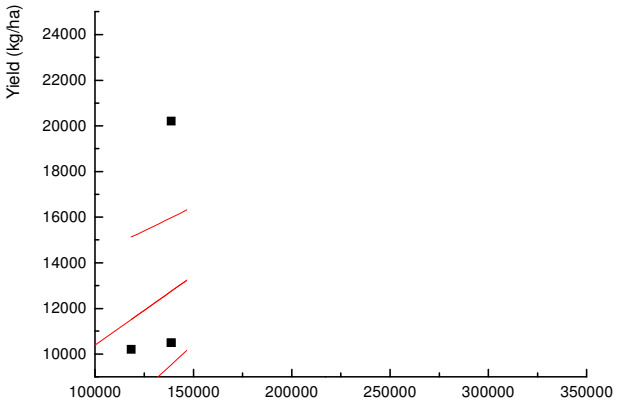


Fig 4: corre

IV. Discussion

The yield variations obtained in the study were associated to the variation of the population density of pests as evidenced by the regression equations. Those between population density of *B. tabaci* at 60th day after the application and the yield is expressed by the following mathematical formula: $Y = -1237,37X + 23645$ with $r = -0,96$ $(p = 5,6569E-7)$; at 90th day after application by $Y = -4179X + 25376,62$ with $r = -0,94$ $(p = 4,8699E-6)$. In relation to *H. armigera*, this is expressed by the following regression equation: $Y = -1114,66X + 25210,29$ with $r = -0,97$ $(p = 2,7682E-7)$ (figure 1, 2). These results confirmed the biological efficiency of the formulations studied with the domestic CITEC soap as adjuvant. This was further attested by the relation between the number of harvested fruits and the yield of tomatoes obtained with the following regression equation: $y = 0,06X + 4309,40$ with $r = 0.89$ $(p = 0.0001)$ (figure 3, 4). This efficiency, however, was related to the properties of the active ingredients in *C. nigricans* and yellow peppers, their persistance of action and the applied rates. Regarding the different properties of *C. nigricans*, studies have demonstrated biological activity attributed to phytochemical constituents polyphenols such as anthraquinones [22, 26-28], flavonoids [29] and polysaccharides [30] present in it. The results of this study, particularly those against whitefly (*B. tabaci*) cotton bollworm (*H. armigera*) confirmed our previous work [22] showing the insecticidal components in *C. nigricans,* particularly emodin on *B. tabaci* adults and larvae of *Anopheles gambiaea*, Citreorosein and emodic acid on larvae of *Anopheles gambiaea* and *Helicoverpa zea.* Phytochemical constituents in *C. annuum* (yellow pepper) also explained its insecticidal effects on white flies [23]. The significant presence of anthraquinones, volatile oils, saponins, sterols and triterpenes in *C. nigricans* extract was responsible for the insecticidal activity [31, 32].

This study, while confirming the insecticidal and repellent activities of these natural extracts, showed better efficiency coefficients against *B. tabaci* with formulations of CITEC soap as adjuvant (Table 3). The enhanced activity may result from synergy related to the chemical

composition of CITEC soap by ensuring better adhesion of active ingredians in the natural extract on tomato leaves and on affected insects than sprays containing adhesol. From the CITEC factory, we got inquires that this soap contain 12% of sodium hydroxide which is well known to have insecticides properties. Against *H. armigera*, we did not notice any difference between the additives and plant extracts. Considering that whitefly is a polyphagous insect and a virus transmission vector causing the destruction of tomato photosynthetic activity, the use of CITEC soap as an adjuvant has significant economic interest. The results confirmed that the aqueous extracts of the yellow pepper formulated with CITEC soap and adhesol as well as extracts of *C. nigricans* formulated with adhesol performed equal or superior to the control synthetic insecticide Deltamethrin (Table 5).

V. Conclusion

Aqueous extracts of *C. annuum* and *C. nigricans* contain active ingredients with insecticidal or repellents properties effective against whitefly (*B. tabaci*) and cotton bollworm (*H. armigera*) on tomato. The aqueous extracts of yellow pepper (250l / ha) formulated with CITEC soap powder (52g /16l) reduced the population density of *B. tabaci* from 28, 14% to 74, 11% and that of the cotton bollworm (*H. armigera*) from 57, 23% compared to the untreated control. Extracts of *C. nigricans* (250l / ha) formulated with CITEC soap powder (52g / 16 l) provided reductions of *B. tabaci* from 35% to 79% and *H. armigera* reduction of 52, 43% when compared to the untreated control. These biological efficiency coefficients did not differ significantly from the control insecticide Decis (Deltamethrin). CITEC soap powder as an alternative additive to adhesol allowed plant aqueous extracts to afford yields equivalent to Decis. Overall, the aqueous extracts of *C. annuum* and *C. nigricans* formulated with adjuvants doubled the yield of tomato compared to the untreated control.

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was born in Kerala, India on June 8, 1951. He is a Professor of Natural Products Chemistry in the Department of Horticulture (Bioactive Natural Products and Phytoceuticals Laboratory) and Senior Associate to the CANR Dean at Michigan State University, East Lansing, Michigan, USA. His research program addresses all aspects of discovery, isolation, and identification of phytochemicals with potential as nutritional/functional food agents and phytomedicines to manage or treat diseases such as cancer, neurodegenerative diseases such as Alzheimer's disease (AD) and Parkinson's disease (PD), musculoskeletal diseases, obesity, type-2 diabetes, inflammation and parasitic/microbial diseases. Product discovery including efficacy, toxicity, and mode of action and dosage of identified phytochemical(s) to facilitate commercialization of such products as functional food constituents/nuraceuticals and phytomedicines is an integtral part of our research program. The phytochemicals of interest are also being evaluated for animal and plant health. Therefore, the core of our research is bioassay-directed discovery, purification and chemical characterization of natural products using anticancer, antioxidant, anti-diabetic, anti-inflammatory, antifungal, antibacterial, nematicidal and insecticidal assays. Professor Nair has published over 220 peer-reviewed research papers with high impact factor and an inventor or co-inventor on 54 US and 32 international patents.
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