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Evaluation of Some Plant Materials as Organic Mulch for the Control of Yam Tuber Beetles (*Heteroligus* sp.) in Delta State, Nigeria

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Abstract: Investigations were carried out in the rainforest ecological zones of Anwai and Ugbolu in Upper Niger Delta to evaluate ten plant materials as organic mulch for the control of yam tuber beetles in 2004/2005 cropping seasons. Field experiments were laid out in Randomized Complete Block Design (RCBD) and replicated 3 times. Results indicated that the 10 plants materials applied at 20 ton ha^{-1} caused varied differences in the feeding activities of the beetle. Across locations and planting seasons, *Cymbopogun citrates* L. and *Ocimum viride* L. were superior as repellant or antifeedant botanicals to the beetle than others evaluated. Plots with these treatments had significantly higher ($p<0.05$) tuber yields and less beetle damages but none caused beetle mortality.

Key words: Yam beetle, organic mulch, yield, damages evaluation, feeding holes, Nigeria

INTRODUCTION

The largest producer of yam in the world is Nigeria with an annual production of 36.72 million metric ton in 2006 (FAO, 2009). There has been steady growth in yam production since 2002 in Nigeria with an average annual growth rate of 6.6% year^{-1} between 2002 and 2006 (FAO, 2009). Despite the steady increase in yam production, many factors were identified to be major constraint to optimum production of this staple food crop. They are high cost of planting materials (yam sets), labour, costs of controlling insect pests particularly the yam tuber beetles. Among the root and tuber crops, yam is the second most important staple food after cassava that can meet the bulk of carbohydrate requirement of the people around the growing region and beyond.

Damage to yam tubers by the dynastic beetles (*Heteroligus* sp.) has posed one of the major constraint to increase yam output. A range of 27.69% damage with mean beetle attack rate of 32.69% which caused a loss of tuber worth #101.09 million ($7858) in market value in Delta state was reported by Inoni (2010). This pest is a very serious insect pest of yam in riverine area, particularly in the forest agro-ecological zone up to savannah region along Benue Niger rivers and tributaries (McNamara and Acholo, 1995; Okoroafor *et al*., 2007).

Yam crop husbandry technologies, particularly pest control should be of low cost, easy to adopt, safe for homestead of growers and readily available. Campaign against the judicious use of synthetic pesticides is of global consciousness. Apart from being expensive and toxic to handlers and environment some insect pest now show resistance therefore, the use of botanical compound may serve as a better substitute (Gold and Messiaen, 2000). In an attempt to reduce residue problem and mammalian toxicity in pesticides, many alternatives to synthetic pesticides are being developed. Many insecticides of plant origin devoid of problem associated with synthetic pesticides for example, *Azadirachta indica* (neem tree), *Allium cepa* (onion), *Musa paradisiaca peels* and *Elaeis guinensis* (mature female inflourecence) have all been found to show pesticidal activities on wide range of insect pests (Arnason *et al*., 1989; Dube and Dwivedi, 1991). Dried leaves of *Ocimum basilicum* used against insect storage pest of maize *Sitophilus zeamais* was reported to exhibit significant positive bioactivity against the insect for 20 weeks (Asawalam and Adesiyan, 2001). Evaluation of seed powders of *Azadirachta indica*, *Jatropha curcas*, *Thevetia peruviana*, *Monodora myristica*, *Piper guineense* and *Carica papaya* against *Cowpea bruchids*, *Calloso bruchus maculatus* showed mortality of the adult bruchids in the laboratory comparable with synthetic insecticide (Emeasor *et al*., 2004).

Mulching is the practice of placing layers of materials either organic or inorganic on the soil surface to reducing the soil temperature and conserve soil water (Simpson, 1987). This is also commonly practiced in gardening. It prevents soil erosion, baking of the soil surface acts as an insulation and buffer, moderating the effect of weather, soil temperature and activities of the soil biological agents (Onwueme, 1978; Foster, 1984; Ikeorgu and Ezumah, 1991). Commonly used mulching materials are dry leaves, grass straw, decomposed manure, synthetic mulching material such as black, white polythene, clear and porous plastic (Mathew and Karikari, 1990; Tobih and Okonmah, 2009). The prime objectives of the study is to evaluate some plant materials as organic mulch for the control of yam beetles in the study area.

MATERIALS AND METHODS

The investigation was carried at the Faculty of Agriculture Teaching and Research Farm, Delta State University, Asaba Campus as well as others at Ugbolu, a village in Oshimili North Local Government Area of Delta state in 2004 and 2005 cropping season. The field at both locations were cleared and pulverized before the yam mound were made with Abakiliki traditional hoe (Ikeorgu and Igwillo, 2002).

Total area for the experiment was 45×11 m (495 m^2), mapped into 23 plots of 5×3 m representing 15 heaps or plots. About 11 treatments of 10 different plants leaves applied as mulch and untreated control were assigned to them in randomized complete block design replicated 3 times.

The space between plot was 1.5 m while it was 2 m between blocks. About 2 kg (20 ton ha^{-1}) of each different plant leaves already dried for 2 days were weighed and applied carefully to cover each yam heaps with some bolls of soil on top to prevent it from being blown off by wind. The scientific name, family, common name and part of the plant used are shown in Table 1. Yam set (*Discorea rotundata* cv *adaka*) weighing 200-250 g of mixed tuber portions were planted in mounds space 1×1 m apart at the rate of 1 set per mound on May 23-24, 2004 and May 19-20, 2005.

After sprouting and vine establishment, the yams were staked using 2.5 m Indian bamboo stakes. Plots were kept weed-free manually by hoeing at 3, 8 and 12 weeks after planting. At harvest (14 and 15th December, 2004 and 19 and 20th December, 2005) the freshly harvested tubers were weighed and beetles damage quantified as the number, depth and diameter of feeding hole per tuber, percentage yield increase over control, the severity of attack and percentage tubers attack by the beetles. Data were subjected to analysis of variance and significantly different means were separated using New Duncan Multiple Range Test (NDMRT) at 5% level of significance.

Table 1: Plants evaluated as organic mulch for the control of yam beetles (*Heteroligus* sp.)

Scientific names	Family	Common name	Plant part used
Azadirachta indica (A) Juss	Meliaceae	Neem tree	Leaves
Acacia sp.	Leguminosae	Asacia	Leaves
Cassia sp.	Leguminosae	Cassia	Leaves
Cymbopogon citrates (L.)	Poaceae	Lemon grass	Leaves
Ocimum viride (L.)	Labitae	Mosquito plant	Leaves
Chromoleana odorata	Asteraceae	-	Leaves
Gymelina arborea	Verbenaceae	Fruit tree	Leaves
Jatropha curcas (L.)	Euphorbiaceae	-	Leaves
Solamum sp.	Solanaceae	Wild egg plant	Leaves
Thevetia speruviana (L.)	Apocynaceae	-	Leaves
Control (no mulching)	-	-	No mulching

RESULTS

The result from the evaluation of some plant materials as organic mulch to control yam beetle at Anwai 2004/2005 cropping season are shown in the Table 1 and 2. Results showed that organic mulch has some significant influence on the yield of yam tubers. *Azadirachta indica* A. Juss (neem) and *Cymbopogon citratus* (lemon grass) plots had higher tuber yield significantly different ($p<0.05$) from *Cassia* sp. and *Jatropha curcas* plots. Table 1 showed that *C. citrates* treated plots showed significantly higher tuber yields than other treatments evaluated excepts plots with *A. indica* leaves which had 30.2 and 25.8% yield increase over control, respectively in 2004 while *Gymelina oborea* and *O. viride* treated plots had yield increases of 5.37 and 0.62%, respectively. Lower tuber yields than the control plots were obtained from plots mulched with *Solanum* and *Cassia* sp. (Table1).

Damage indices indicate that beetle feeding holes were more in plots with *Chromoleana odorata* (Siam weed, 17.40 *Solanum* sp. (wild egg plant), 14.30 and the unmulched control but the differences were not significant ($p>0.05$). Less beetle feeding holes were recorded in plots mulched with *Thevetia peruviana*, *C. citratus*, *O. viride* and *Acassia* sp., which were significantly lower ($p<0.05$) than what were recorded for *C. odorata*, *Solanum* sp. and *A. indica* treated plots. Percentage tubers attacked by the yam beetles were significantly lower ($p<0.05$) in plots treated with *C. citratus* and *O. viride* from the control plots where 82.33% tubers were attacked. Damaged severity scoring was very severe in the control plots followed by severe in plots mulched with Cassia, Solanum, Gymelina and Azadirachta leaves while other treatments had moderate damages.

The results of 2005 cropping season are shown in Table 2. Tuber yield was significantly higher ($p<0.05$) in *C. citratus* mulched plots (20.76 ton ha^{-1}) than other treatment. Other treatments did not show any significant difference ($p>0.05$) from the unmulched control. *C. citratus* expressed its superiority over other mulch by having 53.77% yield increase over the control plots, followed by *O. viride*, *T. peruviana* and *G. aborea* plots with 16.5, 16 and 16% yield increases, respectively over controlled plots. Percentage tuber yields from Solanum, Cassia and Acassia plots were however comparable to

Table 2: Evaluation of some plant materials as organic mulch for the control of yam beetle at Anwai in 2004 season

Treatments	Tuber yield (ton ha^{-1})	Mean no. of feeding holes/tuber	Feeding hole (cm) Depth	Diameter	Tuber attacked (%)	Damaged severity	Yield increase over control (%)
Control	16.00^{bc}	17.91^{a}	1.53^{a}	1.20^{a}	82.33^{a}	4.66^{a}	-
Acacia sp.	13.86^{bc}	8.66^{d}	1.16^{ab}	1.16^{a}	71.00^{abc}	3.66^{abc}	-13.75
Cassia sp.	12.10^{bc}	10.23^{cd}	1.16^{ab}	1.23^{a}	72.00^{abc}	4.0^{abc}	-2.40
Chromoleana odorata	14.10^{bc}	17.40^{ab}	1.23^{ab}	1.30^{a}	69.33^{bcd}	3.66^{abc}	-11.87
Solanum sp.	15.03^{bc}	14.30^{ab}	1.23^{ab}	1.23^{a}	72.66^{abc}	4.33^{ab}	-6.06
Gmelina aborea	16.10^{bc}	10.49^{dc}	1.18^{ab}	1.18^{a}	72.33^{abc}	4.0^{abc}	-0.62
Jathropha curcas	12.76^{bc}	10.50^{dc}	1.36^{ab}	1.10^{a}	66.66^{bcd}	3.00^{c}	-20.25
Cymbopogon citrates	20.84^{a}	6.93^{d}	0.98^{b}	1.16^{a}	58.00^{d}	3.00c	30.25
Azaditracata indica	20.13^{ab}	13.33^{bc}	1.23^{ab}	1.20^{a}	74.66^{ab}	4.33^{ab}	25.81
Ocimum viridi	16.86^{bc}	8.10^{bd}	1.10^{ab}	1.13^{a}	61.33^{cd}	3.33^{bc}	5.37
Thevetia peruviana	13.36^{bc}	7.58^{d}	1.11^{ab}	1.23^{a}	67.00^{bcd}	3.33^{bc}	-16.9
CV (%)	25.62	20.90	18.79	15.42	9.60	16.70	-
SE (±)	0.17	5.69	0.05	0.03	44.89	0.39	-

Means followed by the same letter are not significantly different at 5% level according to New Duncan Multiple Range Test (NDMRT)

Table 3: Evaluation of some plant materials as organic mulch for the control of yam beetle at Anwai in 2005 season

Treatments	Tuber yield (ton ha^{-1})	Mean no. of feeding holes/tuber	Feeding hole (cm) Depth	Diameter	Tuber attacked (%)	Damaged severity	Yield increase over control (%)
Control	13.50^{b}	17.33^{ab}	1.40^{aa}	1.36^{a}	74.33^{a}	4.33^{a}	
Acacia sp.	12.16^{b}	15.66^{abc}	1.16^{ab}	1.06^{a}	61.00^{ab}	3.00^{ab}	-9.92
Cassia sp.	13.00^{b}	10.83^{bcd}	1.16^{ab}	1.16^{a}	67.67^{ab}	3.33^{ab}	-3.70
Chromoleana odorata	14.06^{b}	19.33^{a}	1.13^{ab}	1.20^{a}	65.00^{a}	3.66^{ab}	4.14
Solanum sp.	13.33^{b}	20.33^{a}	1.20^{ab}	1.16^{a}	73.33^{ab}	4.33^{a}	-1.25
Gmelina aborea	15.73^{b}	10.33^{bcd}	1.26^{ab}	1.23^{a}	74.67^{a}	4.00^{ab}	16.51
Jathropha curcas	15.00^{b}	10.66^{bcd}	1.20^{ab}	1.16^{a}	64.00^{ab}	3.33^{ab}	11.11
Cymbopogon citrates	20.76^{a}	5.00^{d}	1.01^{b}	1.00^{a}	47.67^{b}	2.66^{b}	53.77
Azaditracata indica	15.00^{b}	12.66^{abcd}	1.16^{ab}	1.20^{a}	55.67^{ab}	4.33^{a}	11.11
Ocimum viridi	15.66^{b}	7.33^{cd}	1.06^{ab}	1.11^{a}	62.33^{ab}	3.00^{ab}	16.00
Thevetia peruviana	-	9.00^{bcd}	1.16^{ab}	1.16^{a}	67.33^{ab}	3.66^{ab}	16.00
CV (%)	27.89	35.30	14.98	16.38	18.87	22.27	-
SE (±)	0.18	19.75	0.03	0.03	150.95	0.64	-

Means followed by the same letter are not significantly different at 5% level according to New Duncan Multiple Range Test (NDMRT)

control plots. Severity damage range from mild in *C. citratus* treated plot to severe damages in Solanum, Gymelina and Azadirachta teated plots. Percentage of yam tubers with beetle damage was lower in *C. citratus* (47.67%) significantly lower ($p<0.05$) from the control plots with 74.67% in *Gymelina aborea* and 73.33% in Solanum treated plots. Similarly, lower beetle feeding holes were recorded in *C. citratus* plots followed by *O. viride* and *T. peruviana.* Conversely, plots with *solanum* leaves had 20.33, *C. odorata* 19.33 and the control were all significantly higher ($p<0.05$) than *C. citratus*, *O. viride* and *T. peruviana* treated plots. Superiority of *C. citratus* was expressed on the beetle feeding hole number and depth which were significantly different ($p<0.05$) from the control plots and other treatments.

The 2 years study in Anwai showed the superiority of *C. citratus* as organic mulch over other treatments in influencing tuber yields and less damage indices due to the yam beetles. Table 3 shows the results of trials in 2004 at Ugbolu. Tuber yield results indicated *O. viride* (20.11 ton ha^{-1}) and *C. citratus* (17.93 ton ha^{-1}) having the highest which were significantly different ($p<0.05$) from those obtained in Cassia and Solanum treated plots at 5% probability level. Tuber yields in other treatments were comparable with the control plots with no significant differences except plots mulched with *Ocimum viride*. It was generally observed that the use of these plant materials as organic mulch positively influenced and improved the yield of yam tubers (Table 3).

DISCUSSION

The entire 10 plant materials used as organic mulch in this study variously affected the feeding activities of the yam beetles and their attendant damages. The results across the locations and year of cropping consistently show the superiority of *C. citratus* and *O. viride* as a good repellent or antifeedant botanicals to the beetles over the rest botanicals evaluated. Tuber yields from the 2 plant materials were consistently higher than other eight treatments including the control. The efficacy of the 2 plant materials as promising botanical for yam beetle control is further authenticated by the consistent high values obtained in the percentage yield increases (Table 2-5) across the locations and cropping seasons.

Table 4: Evaluation of some plant materials as organic mulch for the control of yam beetle at Ugbolu in 2004 season

Treatments	Tuber yield ($ton\ ha^{-1}$)	Mean no. of feeding holes/tuber	Feeding hole (cm) Depth	Diameter	Tuber attacked (%)	Damaged severity	Yield increase over control (%)
Control	13.33^{bc}	22.33^{q}	1.46^{ab}	1.30^{ab}	74.66^{ab}	3.66^{a}	-
Acacia sp.	13.33^{bc}	15.33^{bcd}	1.23^{ab}	1.10^{b}	56.66^{b}	3.33^{a}	0.00
Cassia sp.	10.16^{c}	12.66^{dc}	1.30^{ab}	1.16^{ab}	66.66^{ab}	3.33^{q}	-23.78
Chromoleana odorata	15.83^{bc}	18.33^{abc}	1.30^{ab}	1.20^{ab}	63.33^{ab}	3.33^{a}	18.75
Solanum sp.	11.60^{c}	20.00^{ab}	1.33^{ab}	1.43^{a}	75.66^{a}	4.33^{a}	12.97
Gmelina aborea	14.20^{bc}	12.00^{dc}	1.18^{ab}	1.20^{ab}	68.00^{ab}	3.66^{a}	6.52
Jathropha curcas	14.93^{bc}	14.66^{cd}	1.10^{ab}	1.06^{b}	64.66^{ab}	3.66^{a}	12.00
Cymbopogon citrates	17.93^{ab}	9.00^{c}	0.87^{b}	1.40^{a}	58.66^{ab}	3.00^{a}	34.50
Azaditracata indica	13.76^{bc}	17.66^{abc}	2.40^{a}	1.10^{b}	67.66^{ab}	3.66^{a}	3.22
Ocimum viridi	20.11^{a}	10.66^{dc}	1.20^{ab}	1.16^{ab}	63.33^{ab}	3.33^{a}	50.86
Thevetia peruviana	13.93^{bc}	12.00^{dc}	0.76^{b}	1.43^{a}	65.00^{ab}	3.33^{a}	4.50
CV (%)	19.96	17.67	55.38	11.85	14.47	20.89	-
SE (±)	0.08	7.00	0.5	0.02	90.86	0.53	-

Means followed by the same letter are not significantly different at 5% level according to New Duncan Multiple Range Test (NDMRT)

Table 5: Evaluation of some plant materials as organic mulch for the control of yam beetle at Ugbolu in 2005 season

Treatments	Tuber yield ($ton\ ha^{-1}$)	Mean no. of feeding holes/tuber	Feeding hole (cm) Depth	Diameter	Tuber attacked (%)	Damaged severity	Yield increase over control (%)
Control	10.66^{c}	21.66^{a}	1.50^{a}	1.40^{a}	78.33^{a}	4.33^{ab}	-
Acacia sp.	15.00^{bc}	11.00^{cd}	1.26^{ab}	1.16^{a}	61.66^{dc}	3.00^{b}	40.71
Cassia sp.	11.66^{c}	12.00^{cd}	1.33^{ab}	1.16^{a}	66.66^{dc}	3.66^{ab}	9.38
Chromoleana odorata	12.43^{c}	12.33^{cd}	1.36^{ab}	1.23^{a}	73.00^{abc}	4.66^{ab}	16.6
Solanum sp.	11.50^{c}	20.00^{ab}	1.43^{a}	1.15^{a}	73.00^{abc}	4.00^{ab}	7.87
Gmelina aborea	12.00^{c}	12.00^{cd}	1.30^{ab}	1.16^{a}	72.66^{abc}	4.00^{ab}	12.57
Jathropha curcas	14.66^{bc}	12.00^{cd}	1.30^{ab}	1.16^{a}	61.33^{dc}	3.00^{b}	38.52
Cymbopogon citrates	20.40^{a}	7.33^{d}	0.90^{b}	1.06^{a}	55.66^{c}	3.00^{b}	91.36
Azaditracata indica	14.33^{bc}	14.33^{bc}	1.33^{ab}	1.40^{a}	76.33^{ab}	4.00^{ab}	34.42
Ocimum viridi	20.06^{ab}	8.66^{cd}	1.00^{ab}	1.13^{a}	76.33^{ab}	3.00^{b}	88.18
Thevetia peruviana	17.66^{abc}	11.33^{cd}	1.23^{ab}	1.30^{a}	69.33^{bcd}	3.66^{ab}	65.66
CV (%)	24.11	26.27	20.42	14.24	60.60	18.99	-
SE (±)	0.13	11.61	0.06	0.02	16.89	0.48	-

Means followed by the same letter are not significantly different at 5% level according to New Duncan Multiple Range Test (NDMRT)

None of the plant materials caused beetle mortality because no dead beetle was seen during tuber harvest. Application of plant materials to the soil as much has been reported to increase soil nutrients and organic matter contents. This also moderates soil temperature, increase moisture infiltration, aeration and increase activities of micro and macro-organisms in the soil while weeds are suppressed with resultant increase in crop yield (Kang *et al*., 1990).

This report was consistent with the outcome of this study where plots with organic materials had higher tuber yields than the unmulched except in some cases where control had higher tuber yields as observed with treatments with *Accasia*, *Cassia*, *Solanum* and *Jatropha* sp. The reasons for the lower yield in these treatments compared with control is unknown and need to be further investigated. Mulching with grass chippings was reported to increase the yield of cauli flower and reduced damage by brassica root maggot *Delia* sp. (Hellqvist, 1996). Widespread use of plants or its parts placed in the field or applied as herbal concoctions for pest control and inhibition was reported by Attieri (1993). Peasant farmers in Ecuador for example, placed castor oil leaves in newly planted maize field to reduce population density of Tenebrionid beetle. Branches of *Cestrum parqu* was reported to be commonly placed in potato fields by peasant farmers in southern Chile to ward-off or repel heavy population of *Epicanta pilme* beetle (Altieri and Farrell, 1984).

Earliest attempt made to control yam beetle without synthetic chemical was the planting of *Cymbopogon* sp. in alternate rows with yam which was reported to cause a little decrease in damaged tuber (Lean, 1929). Thereafter, no study reported the use of plant materials either as live much or organic to control yam beetle menace. The use of various plant materials either as aqueous extract, extracted oils or seed powders have been widely reported and documented by several workers to control insect pests (Dike and Mba, 1992; Ivbijaro, 1983; Adedire and Ajayi, 1996; Ivbijaro and Bolaji, 1990). *Cymbopogon citratus* for example was reported by Olaifa *et al.* (1987) to control field insect pest such as *Dysdercus volkeri* (Fab), *Ootheca mutabilis Salhb* and *Riptortus dentipes* while *Ocimum suave* was considered to be an effective repellant against *Sitophilus zeamays* (Hassanali *et al*., 1990). Interestingly, some plant leaves used in this study has also been reported to possess some insecticidal properties. For example, Oparaeke and Dike (1996) reported that *C. citratus* was effective against cowpea bruchid, *Collosobruchus maculatus* F. It was also found to be effecctive against *Sitophilus zemays* (Adedire and Ajayi, 1996; Asawalam and Adesiyan, 2001). The genus *Cymbopogon* sp. was reported to be very rich in geranoil content to which the insecticidal properties are attributed. Insecticidal activity of some seed powders against Callosobruchus on stored cowpea was evaluated and *Thevetia peruviana*, *Jatropha curcas* and *Azadirachta indica* were among the very effective powders out of the eight seed powders reported (Emeasor *et al*., 2004). Similarly, crude extract of neem (*Azadirachta indica*) and two other botanicals were successfully used to control the menace of *Anoplocnemis curvipes*, *Clavigralla shadabi* and *Maruca vitrata* all insect pests of cowpea during the dry season and grain yield significantly increased (Epidi *et al*., 2005).

Powders prepared from part of eight different plant species among which were Ocimum and Chromoleana and tested in the laboratory against maize weevils (*Sitophilus zeamais*), showed increased mortality and reduced adult emergence of the weevil (Asawalam *et al*., 2006). *Cassia nigricans* leaves were used to protect cowpea seed from attack by the pulse beetle in Upper Volta (Lambert *et al*., 1985) while the bark, fruit and roots of *Jatropha curcas* are all reported to contain hydrogen cyanide in addition to toxalbumin and curcin as active ingredients believed to be insecticidal against many insect pests. Studies conducted by Inyang (2004) in the laboratory, revealed that 10% aqueous extracts of 13 botanicals among which were *A. indica*, *C. citratus*, *Ocimum gratissimum* deterred feeding and repelled banana/plantain weevil *Cosmopolites sordidus* (germar) but did not cause acute mortality in the insect. Results obtained from this study, showed that not all the botanicals used as organic much were effective. However, *O. viride* and *C. citratus* which show some degree of protection against the infestation and damage by the yam beetle could be incorporated under integrated control of the yam beetles possibly as much or as a row plants.

CONCLUSION

The results from this study consistently show the potentials of *C. citratus* and *O. viride* as promising antifeedant in the botanicals for the management of yam beetle. They showed significant reduction of beetle damages on yam tubers. Their mode of action is yet unknown. It is suggested therefore that further studies be carried out on this aspect.

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