Evaluation of Whitefly Population and Weather Effect of Cassava Mosaic Incidence on Commonly Grown Cassava in Benue State, Nigeria

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ABSTRACT: Vector population and weather are critical in virus disease incidence and could be strategic for its management in agriculture. To investigate the influence of whitefly population and weather on Cassava Mosaic Disease (CMD) in cassava, TMS 419 and TME 30572, commonly grown in the state were planted. The varieties were laid out in Randomized Complete Block Design in four replicates and left to natural infection by CMD viruses. At two weeks after planting and fortnightly, whitefly population counts were taken, CMD incidence was estimated and severity scored on 5-point scale. Daily temperature, humidity, wind speed and wind direction were obtained as secondary data. Data were analysed using ANOVA at p=0.05. Whitefly population (18/plant) was significant $_{(P \leq 0.05)}$ in the first 30 days at 26.9-27.1℃, 42% humidity, 10 Km/hr wind speed and when the wind direction was in the East or North-East. The vector population then declined until the end of experiment. Cassava mosaic incidence changed with whitefly population, humidity and wind speed. Disease incidence in cassava plots was low (3.6%). TME30572 maintained lower disease incidence (3.0%) and severity (2.0) during the study. R^2 indicated that 27, 42 and 57% of whitefly population could be explained by temperature, humidity and wind speed, respectively while 4% of the disease incidence could be explained by the whitefly population. The number of CMD infected plants peaked (4%) when population of whitefly was 18/plant, above which the disease reduced at 0.0017 rate per unit change in the vector population. Mosaic disease incidence in cassava plots was influenced by vector population as conditioned by the weather.

Cassava (*Manihot esculenta* Cranz) is a perennial shrub in the family *Euphorbiaceae* and a native to Latin America. Being a main staple in Africa, the crop is widely grown for food and feed for humans and livestock, respectively in many developing countries (Abaca *et al*., 2012). It is easy to grow and it thrives well in poor soils with little water and even under adverse climatic conditions. It offers several other industrial benefits such as starch and alcohol production (Nduele, 1993; Atthasampunna *et al*., 1987). Potentials of cassava yield have not been achieved in Africa, in spite of the large hectarage of land that is dedicated to its cultivation; this is due to several production constraints which has hampered maximum yield of this important crop (Legg, *et al*., 2015). Many diseases have been reported attacking the species, of which cassava mosaic disease (CMD) is ranked the most severe and widespread in sub Saharan Africa (Kaitisha 2003; Legg, *et al*., 2015). Yield losses resulting from mosaic diseases are responsible for some of the most severe crop losses of cassava in Africa. Whiteflies are the vectors associated with transmission of cassava mosaic in cassava fields.

Effective vector control has being a comprehensive strategy to disease management, particularly those of virus origin. In a standpoint of searching for effective strategy for fighting CMD, whitefly control could be targeted in a management of the disease (Thresh *et al.,* 1997). Objectives of the study were to assess incidence and severity of the CMD on two cassava varieties, establish a relationship among incidence of the disease, whitefly population and some weather factors under field conditions in Makurdi.

MATERIALS AND METHODS

Source of Materials and Experimental Site: Stem cuttings of the two cassava varieties, TMS 30572 and TME 419, were obtained from the International Institute of Tropical Agriculture (IITA) by the Cassava Weed Management Project (CWMP).

The experiment was carried out in the University of Agriculture, Makurdi, as part of the CWMP. The site was situated between Latitude 07^0 47'N and Longitude 08^0 37'E at an elevation of 107m above sea level.

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Field Layout and Experimental Design: A 380m^2 land was ploughed and harrowed after which 340m^2 portion was marked out for the experimental layout. The trial was laid out in a Randomized Complete Block Design (RCBD) and replicated four times. That is, the 340m^2 portion was demarcated into four blocks each measuring 17m long × 4m wide. Blocks were separated from each other by 1m inter-space. A block was divided further into two plots with 4m × 6m dimension per plot. One plot was given to each variety in each replication. Planting was done at the crest of raised ridges and 2cm cuttings of each variety were planted per stand at about 7cm depth. Twenty-five cuttings were planted per ridge and eight ridges made up a plot, the spacing was 1m × 1m intra and inter-row giving a plant population of 200 plants per plot in eight rows of 25 plants per row. Missing stands, i.e. those that did not sprout were supplied one week after sprouting. Agronomic activities recommended for cassava management were carried out by the CWMP team.

Data collection and statistical analysis: Whitefly sampling: Cassava plants were sampled at random for whiteflies along the diagonal paths running through plots in 'X' pattern following the procedure by Chikoti *et al.* (2015). A total of 20 plants were assessed per plot, 10 from each diagonal. Individual plot sampling involved scouting and counting the number of whiteflies on each plot selected per time. Each leaf was observed closely for whitefly at the abaxial part of the leaves sampled. Sampling of adults and nymph insect vectors was carried out in the morning and evening when the adult whiteflies were inactive.

Cassava Mosaic Disease Incidence and Severity Assessment: Mosaic disease assessment in cassava plots was carried out as described by Hahn *et al.* (1980) and Otim-Nape (1993). The incidence of cassava mosaic disease (D1) for a variety was estimated as a ratio of the number of plants showing mosaic symptoms and the total number of plants considered in a plot and expressed as a percentage.

$$D1 = \frac{CPM}{TPC} \times \frac{100}{1}$$

Where CPM = number of cassava plants showing mosaic symptoms and TPC = Total number of plants considered in a plot

Severity (DS) of cassava mosaic for each plot showing symptoms was measured on a 5-point scale. Severity scale which ranged from 1-5 had 1-symptomless or apparently healthy to 5-severe mosaic and distortion of four-fifth or more of the leaves. When computing the average severity, scores for the non symptomatic plants were left out and not considered (Sseruwagi *et al.*, 2003). Data on whitefly count, disease incidence and severity were collected at two weeks intervals for sixteen weeks from November, 2015 to February, 2016. Daily weather readings such as temperature (°C), relative humidity (%), wind speed (Km/hr) and wind direction during the period of experiment were obtained from the Nigeria Air Force Meteorological Station, Nigeria Air Force Base, Makurdi. Data collected were analyzed using ANOVA and means separated using FLSD (p≤0.05).

RESULTS AND DISCUSSION

Whitefly population: Whitefly mean population was low (8 per plant). The vector population peaked (18 per plant) in cassava plots only in the first 30days of the study (Table 1). This however, declined (9, 4, 3 and 2 per plant) continuously until no whiteflies were observed in the field. Except at 4WAP, TMS 30572 maintained a lower vector population all through the period of study.

Incidence and severity of CMD in cassava varieties under field conditions: None of the two varieties used in the investigation was immune to CMD infection. Significant difference (P≤0.05) in the incidence of CMD was recorded only at 4 WAP (Table 2). Disease incidence was generally low (3.6%) in cassava plots. TMS 419 and TME 30572 had overall mean incidence of 4.2 % and 3.0 %, respectively. Incidence of disease was higher (4.0%) at 4 WAP and 12 WAP during the study. TME 30572 maintained lower (3.0%) disease incidence all through the experiment. There was no significant difference (P≥0.05) in the severity of CMD in cassava plots. Symptoms severity was low (2.0) across cassava varieties. TME 30572 was lower (2.0) in severity all through except at 16 WAP.

Influence of temperature, humidity, and wind speed and wind direction on whitefly population build up in cassava plots: Although rainfall is a critical component of weather particularly with respect to disease studies, there was no rainfall during the period of study, hence no data was considered. Mean temperature in the cassava field was 27.1°C at the start of the experiment (12th November, 2015) which dropped to 24.6°C in the next 34 days (Figure 1). This increased to 33.9°C in the following 76days. Within this period, the whitefly count remained constant at 18 per plant in the first 18days (12 to 30th November, 2015) and then declined to 9 per plant in the next 31 days. The number per plant further decreased to two during the following 45 days and then to zero per plant at the last 15days.

Table 1. Whitefly Population Count on Two Cassava Varieties under Field Conditions in Makurdi

Variety	Mean	Weeks after planting							
		2	4	6	8	10	12	14	16
TME 419	8.1	20.2	16.2	8.9	10.0	4.3	2.7	2.2	0.0
TMS 30572	7.6	16.0	19.9	8.9	7.7	2.9	3.0	2.2	0.0
Mean	7.8	18.1	18.1	8.9	8.9	3.6	2.9	2.2	0.0
LSD (0.05)	**0.7**	**7.0**	**4.7**	**1.4**	**2.4**	**1.6**	**1.5**	**1.0**	**0.0**

Table 2. Incidence and symptom severity of mosaic disease in two CMD-resistant cassava varieties under field conditions in Makurdi

Parameter	Cassava Variety	Weeks after planting								Mean
		2	4	6	8	10	12	14	16	
CMD incidence (%)	TMS 419	3.7	5.5	4.3	3.3	4.5	4.5	4.0	3.5	4.2
	TME 30572	3.1	2.4	3.4	2.9	3.3	3.5	3.2	2.7	3.0
	Mean	3.4	4.0	3.9	3.1	3.9	4.0	3.6	3.1	3.6
	LSD (0.05)	**1.9**	**1.9**	**5.2**	**3.0**	**3.8**	**4.9**	**4.5**	**2.4**	**0.8**
CMD severity (1-5)	TMS 419	2.2	2.0	2.1	1.9	1.9	2.1	2.3	2.0	2.1
	TME 30572	2.1	1.9	1.9	1.9	1.9	1.8	2.0	2.3	2.0
	Mean	2.1	1.9	2.0	1.9	1.9	2.0	2.1	2.2	2.0
	LSD (0.05)	**0.2**	**0.4**	**0.5**	**0.7**	**0.7**	**1.3**	**0.7**	**0.7**	**0.2**

CMD = Cassava mosaic disease

The quadratic polynomial for relationship between temperature and whitefly population in cassava plots was observed as $y = -0.0377x^2 + 0.9139x + 11.709$ ($R^2 = 0.2669$) (Figure 2). The equation showed that whitefly population peaked (18 per plant) at 26.9 – 27.1°C and beyond or below this temperature the population declined continuously at 0.0377 rate per unit change in temperature. Percentage humidity in cassava plot during the experiment ranged from 14 to 59 % (Figure 3).

The number of whitefly decreased continuously from 18 per plant to two in 63days. The equation $Y = 0.0257x^2 + 1.947x – 20.55$ ($R^2 = 0.4192$) shows a polynomial relationship with wind, humidity and the build up of whitefly population in the cassava field (Figure 4). The relationship revealed a negative effect of humidity on the build up of whitefly population in the field. The population of whitefly peaked (18 per plant) at 42% humidity above which the population reduced at 0.0321 rate for every change in humidity. The speed of wind in cassava plots varied continually all through the period of study (Figure 5). Wind speed remained somewhat constant 9.9 to 10.0km/hr in the first 18days of the experiment (November 12 to 30th November 2015), from where it rose sharply to 15.0km/hr at mid-December, 2015. The speed then declined to 13.5km/hr from the end of December and rose steadily for 30days to 14.9km/hr. Speed of wind picked up again from another decline to peak at 23.1km/hr in the last 15days of the study. The quadratic polynomial, $Y = 0.1284x^2 – 5.3441x + 55.316$ ($R^2 = 0.577$) defined the relationship between wind speed and whitefly population (Figure 6). The R^2 value was high and indicated that about 57.7% of the whitefly population can be accounted for by wind speed.
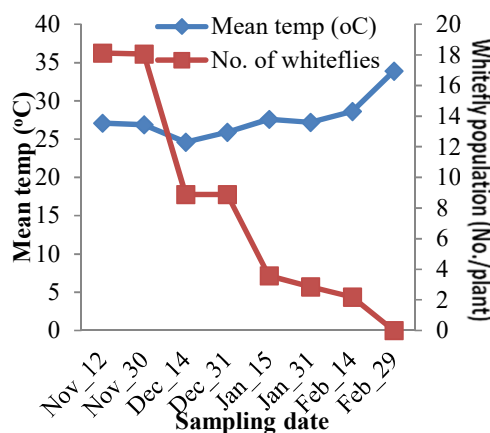

Fig 1. Whitefly population influenced by temperature from November 12, 2015 to February 29, 2016 in cassava plots.
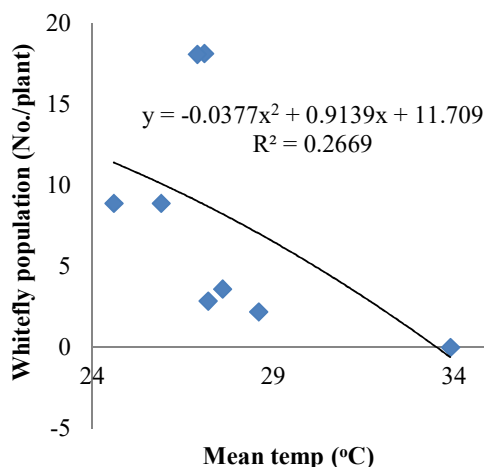

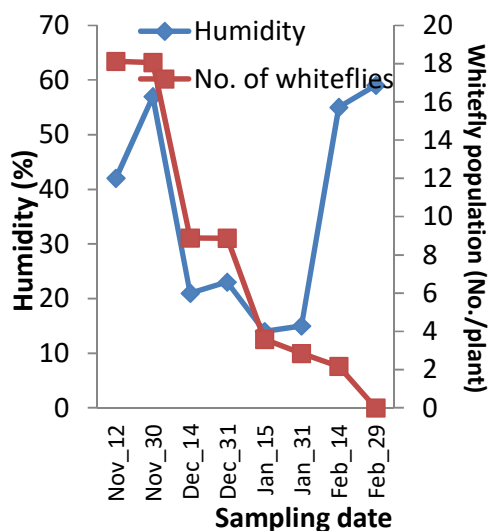**Fig 2**. Relationship between mean temperature and whitefly population in cassava plots.

$y = -0.0377x^2 + 0.9139x + 11.709$
$R^2 = 0.2669$

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Figure 3. Whitefly population influenced by relative humidity from November 12, 2015 to February 29, 2016 in cassava plots.

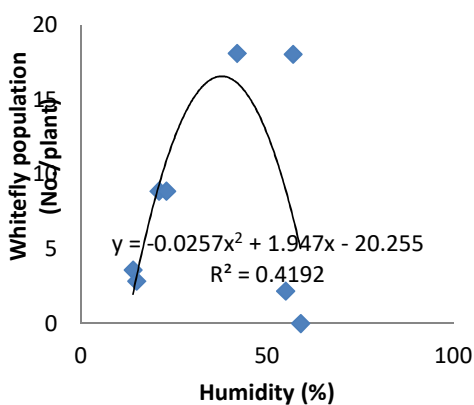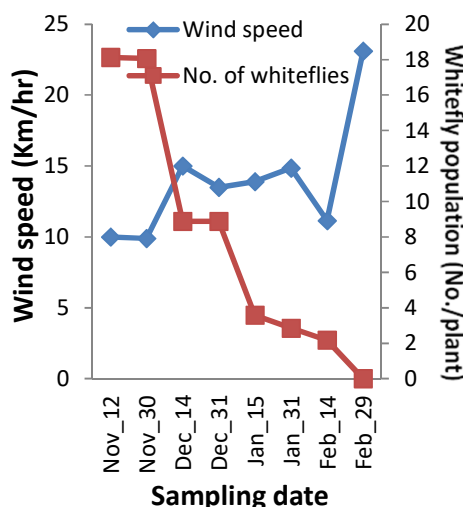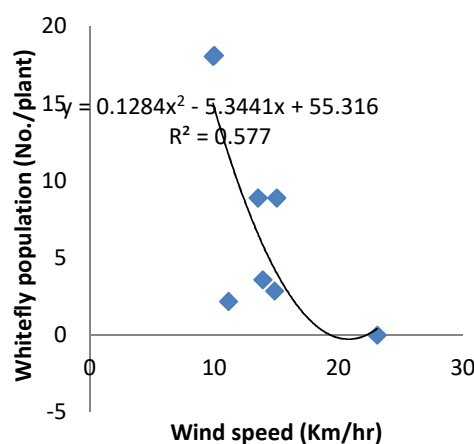**Fig 5**. Whitefly population influenced by wind speed from November 12, 2015 to February 29, 2016 in cassava plots.

Fig 4. Relationship between relative humidity and whitefly population in cassava plots.

Fig 6. Relationship between wind speed and whitefly population in cassava plots.

The equation also indicated that the number of whitefly per plant was highest (18 per plant) when wind speed was low (10.0km/hr) beyond which whitefly population decreased at 0.1284 rate per unit change in speed. Direction of wind across the cassava plots was more to the North followed by the East (Table 3). Whitefly counts were higher in the field when the direction of wind was either to the East (36 and 18km/hr) or North-East particularly from the start of the experiment for 18days to the end of the study. Whitefly count fell drastically (7 - 0 per plant) when the wind change direction to the West, particularly to the North-North-West.

Build-up of whitefly population and its relationship with the incidence of CMD in cassava plots:

Although, the number of infected plants was generally low (<5%) and somewhat constant (3 - 4%), it rose to highest (4%) at 18 and 80days during the study (Figure 7). Number of infected plants finally dovetailed to 3.1% by the end of the study. Quadratic polynomials $Y = 0.0017x^2 + 0.0403x + 3.4747$ ($R^2 = 0.0403$) revealed the relationship between whitefly population build up and CMD incidence in cassava field (Figure 8). The relationship was positive, although neither significant ($P>0.05$) nor strong (0.01). The R^2 value which was low indicated that only 4% of the disease incidence could be explained by the population of whitefly. The equation suggests also that the number of plants infected with CMD was highest (3.6%) when whitefly population was 10 per plant, beyond which the disease decreased at 0.0017 rate per unit change in whitefly population.

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Table 3. Whitefly population as influenced by wind direction in cassava plots in Makurdi.

Month	Date	Wind direction*	Whitefly population (No./plant) on		Total
			TMS 419	TME 30572	
November	12th	E	20	16	36
	30th	NE	16	20	36
December	14th	NE	9	9	18
	31st	NNW	10	8	18
January	15th	SW	4	3	7
	31st	SW	3	3	6
February	14th	NNW	2	2	4
	29th	NE	0	0	0

E - East; N - North; S - South; W – West. Source: Meteorological Station, College of Agronomy, University of Agriculture, Makurdi

Low average population (8 per plant) of whitefly as observed in the cassava plots suggests resistance of the varieties to the vector involved. Moreso, lower vector population on TMS 30572 which was maintained all through the period of study when compared with TME 419, reveals a greater resistance by the variety. Golding (1936) first noted that cassava varieties with greater resistance to CMD supported lower numbers of *B. tabaci*. Population of the whiteflies which peaked only in the first 30days (2 - 4WAP) of the cassava growth and its decline thereafter is a notable phenomenon, as observed by several other authorities. Rahman *et al*. (2006) observed a similar trend, although in tomato plots. Squire (1961) also reported increases in numbers of the vector associated with rapid cassava growth in their young stages. However, clearly apparent were the declines in the whitefly numbers during periods of slow cassava growth due to maturity. The phenomenon is therefore, attributed to preference of the succulent nature of the plants in their young stages by the insect vector. *B. tabaci* populations have consistently been reported to peak in the early stages of the crop, before declining more or less rapidly to a relatively low level for the remainder of the crop life (Fishpool *et al*., 1995). Continuous reduction in whitefly population might be due to maturity of the crop, which clearly does not favour the vector.
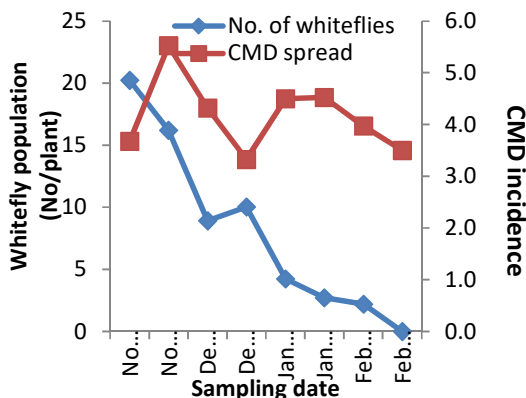

Fig 8. Relationship between population of whitefly and CMD incidence.

$$y = -0.0017x^2 + 0.0403x + 3.4747 \ (R^2 = 0.0403)$$

$$r = 0.01434 \ (P > 0.05)$$

This observation corroborates Bock (1994) and Adebambo (1998) who recorded similar trends in two cassava varieties from July to September in their experiments. Rahman *et al*. (2006) observed that availability of preferred weedy plants outside the field could also reduce vector population. Squire (1961) provided the first suggestion that the physiological age of cassava plants was an important determinant of the pattern of *B. tabaci* population development, by demonstrating a decline in size of population as plants matured. Dengel (1981) and IITA (1990) recorded tuberisation in cassava roots as commencing 30 - 60 days after planting, suggesting that the diversion of photosynthates associated with this change is likely to render aerial parts of the plant less suitable as feeding sites for *B. tabaci*. Observed low disease incidence and severity in cassava plots may also be as a result of resistance of these varieties to CMD infection. Again, similar observations were reported by Adebambo (1998) in the humid rainforest region of Nigeria. Severity of disease obtained in TMS 419 and TME 30572 were not significantly different throughout duration of the experiment. TMS 30572, however, recorded a lower disease incidence and symptom severity all through the experiment. This could suggest a superior resistance trait in TME 30572 to CMD over

Fig 7. Incidence of CMD in cassava plots in relation to whitefly population between November 12, 2015 and February 29, 2016.
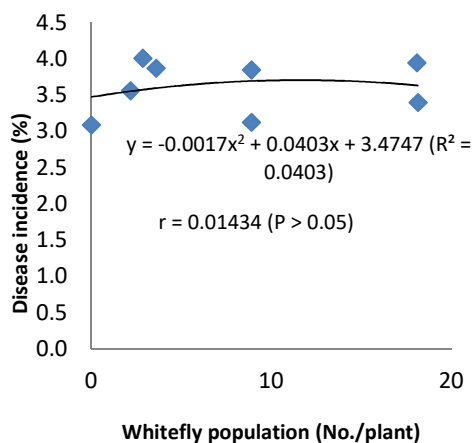
TMS 419. Steady increase in the mean temperature from mid-December to the end of the experiment was observed to correspond with a decline in the population of whitefly. This is in disagreement with Gupta (2000), who observed a positive correlation between temperature increase and whitefly population. Effect of temperature on whitefly population in this study is somewhat similar to other regions like Pakistan (Muhammad *et al.*, 2017). Legg (1994) in Uganda, cited a publication by Legg and Fishpool (unpublished data), that numbers of *B. tabaci* and virus incidence were greatest in multi-location trials in locations with highest temperatures and that high whitefly populations occur during the main rainy season (April - June) following a period of hot dry weather in West Africa.

Root mean square (R^2) values indicated that about 42% of the whitefly population in the cassava plots can be explained by humidity. Also, in spite of considerable fluctuation in the percentage humidity, the quadratic equation revealed positive relationship with the whitefly population suggesting a favourable effect on the vector population. This observation, however contradicts other authorities (Rahman, 2006; Zeshan *et al.*, 2015; Muhammad *et al.*, 2017) whose results were contrary. This observation needs a further investigation with proper care for clarity and confirmation. Although, the root mean square (R^2) values which indicated about 58% of the whitefly population in the cassava plots as influenced by wind speed, Legg (1994) noted that the importance of wind has been emphasized in facilitating dispersion of the vector. That those distances *B. tabaci* adults can move successfully in wind currents are clearly essential in their ability to colonise new cassava fields and introduce CMD. The direction and speed of wind are known to influence distant and trivial movements of whitefly because of their abilities for sustained flights and into head winds (Isaacs *et al.*, 2013). Wind is a critical factor influencing the incidence of viruses by air borne vectors. Prevailing winds also affect the direction of flight of the vectors.

The positive, low and weak value of the root mean square (R^2) in the polynomial equation between whitefly population and CMD incidence simply indicates that a relationship exists between the two. However, only a small proportion of the disease incidence can be explained by the whitefly population. The polynomial relationship also indicated that the rate of CMD infection in cassava plants was low (0.0017) for every change in whitefly population. Weather elements are among factors determining whitefly population dynamics and vector activity from season to season. Data from this study would be useful in formulating efficient management approaches against whitefly vectoring CMD viruses in cassava crop for increased productivity. Further work should consider exploring the effects of humidity on population of the whitefly vector and CMD incidence to clarify the contrast between results in this study and data from other authorities as noted.

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