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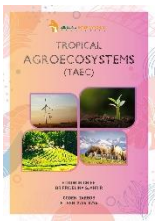

RESEARCH ARTICLE

BIOPESTICIDAL EFFECTS OF NEEM LEAF EXTRACT FOR THE MANAGEMENT OF FALL ARMYWORM *(Spodoptera frugiperda)* ON MAIZE *(Zea mays* L.*)*

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ABSTRACT

Maize is one of the important cereal crops in sub-Saharan Africa (SSA) and an important staple food for more than 1.2 billion people in (SSA) and Latin America. Inspite of this, a study was conducted to investigate the effect of Neem Extract in the control of fall armyworm (*Spodoptera frugiperda*) on some maize varieties such as Sammaz 15, Rido 9, Sammaz 34, Kapan 6, Oba 98, and Oba super 6. The experiment was laid down in Randomized Complete Block Design (RCBD) with three replications. Six varieties of maize were evaluated in Minna, Nigeria during 2021 cropping season. Growth and yield parameter were recorded. The data were subjected to analysis of variance. Results revealed that the effect of Neem Extract varied among the six maize varieties in control of fall armyworm. Sammaz 34, Sammaz 15, and Oba 98 were superior in most of growth and yield parameter. These three varieties could be adopted for breeding for high yield and tolerant to fall armyworm in the study area.

KEYWORDS

Neem extracts, maize, fall armyworm, varieties, *Spodoptera frugiperda*

1. INTRODUCTION

Maize (*Zea mays* L.) belongs to the family of grasses *(Poaceae).* It is grown, as amongst the most important cereal crops worldwide. Maize was domesticated in Central Mexico (Matsuoka *et al.,* 2002) around 6,000 - 9,000 years ago (Benz, 2000). Maize crop is a key source of food and livelihood for millions of people in many countries of the world. It is produced extensively in Nigeria, where it is consumed roasted, baked, fried, pounded or fermented (Agbato, 2003). Maize has been in the diet of Nigerians for centuries. It started as a subsistence crop and has gradually become more important crop. Maize has now risen to a commercial crop on which many agro-based industries depend on as raw materials. The first attempt at Agricultural research in Nigeria was made in 1899 (Fakorede *et al.,* 1993).

Fall armyworm (FAW) can be one of the most difficult insect pests to control in filed corn. Late planted field and late maturing hybrids are more likely to become infested. Fall army worm causes serious leaf feeding damage as well as direct injury to the ear. Fall army worm can damage corn plant in nearly all stages of development, it will concentrate on later plantings that have not yet silked. Fall Armyworm larva feed on maize and cause significant yield losses if not well managed. It ca n have several generations per year and the moth can fly up to 100 km per night. FAW is a potentially damaging transboundary pest that will continue to spread due to its biological characteristics and high volumes of trade between African countries. Farmers will need substantial support to sustainably manage this new pest in their cropping systems using integrated pest management (IPM).

The management of insect pests largely depends on the use of synthetic insecticides in the field and store, however indiscriminate use of many synthetic insecticide in association field, human technician's, environmental non target organisms, resistance of insect pest, food and product contamination with toxic residue, biodiversity, erosion and other side effects. In addition, non-availability of insecticides to country side farmers and ventilation restriction in stored grain are the negative effects of synthetic chemicals. On the other hand, botanical insecticides are naturally occurring chemical extracted from plants which break down readily in the soil and are not stored in plant or animal tissue. Often their effect are not long lasting as those of synthetic pesticides (Ebenezer, 2010). Botanical insecticides are generally pest – specific and are relatively harmless to non-target organisms. They are biodegradable and harmless to the environment. Also, the possibility of insect developing resistance to botanical insecticide is less likely (Isman, 2013). Laboratory and field tests have shown the effectiveness of this plant extracts against armyworm, leaf-cutting caterpillars, ants, whiteflies and the three stages of mosquitoes (Zhen and Zhang, 2009).

Fall Armyworm *(Spodoptera frugiperda)* seriously limits the potential of attainable maize yield in Nigeria and Africa at large. Fall armyworm causes direct injury to the ear which led to the loss of maize yield. Being a recently discovered insect pest, little work has been done to proffer its effective control measures in Nigeria. This research work is to test for the efficiency of neem leaf extract as bio pesticide to control the infestation of fall armyworm maize crop and boost yield of maize crop in Nigeria. The result obtained could be recommended to the maize growing farmers in Nigeria, for the control of fall armyworm on their fields which also encourage the farmers to engage in large cultivation of maize. Knowledge of control over Fall Armyworm by the farmer will increase the income of the maize growing farmers in Nigeria. Therefore, the objectives of this study were to: determine the effect of Neem leaf extract on the management of fall armyworm and obtain the varieties that are tolerant to the infestation of fall armyworm

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2. Materials and Methods

2.1 Experimental Site

The field experiment was conducted during 2021 rainy season at the Teaching and Research farm of School of Agriculture and Agricultural Technology, Federal University of Technology Minna, Gidan Kwano Campus (Longitude 6.3°E Latitude 9.37°N with altitude 1475m above sea level) located in the Southern Guinea Savannah agro-ecological zone of Nigeria. It has a peak temperature of 40°c from March to April. The mean annual rainfall ranges from 120-130 mm.

2.2 Source of Experimental Materials

Six maize varieties were obtained from Institute of Agricultural Research (IAR), Ahmadu Bello University, Samaru Zaria, Kaduna state, Nigeria. The maize varieties are; SAMMAZ 15, RIDO 9, SAMMAZ 34, KAPAN 6, OBA 98 and OBA SUPER 6. The neem leaves were plucked around the School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, premises.

2.3 Extraction and Application of Neem Leaf Extract

Neem leaves were collected and washed with clean water. 1 kg of neem leaves was weighed using weighing balance scale in the Laboratory then chopped with the use of knife into smaller pieces and blended using electric blender with 1 litre of distilled water and mixed properly. Aluminium foil was used to cover the concentration to prevent evaporation, dirt and dust, after which the samples were kept for 24hours on the laboratory bench. After 24hours, the solution was stirred and sieved using muslin cloth. Half litre of neem extract was added to 13 litres of water for the spraying of maize plant using knapsack sprayer.

2.4 Experimental Design and Field Layout

The treatments were arranged in randomized complete block design (RCBD) with three replicates. The net plot size was 14 x 15m^2. Each replicate consisted of 6 plots, replicate measuring 14 x 4.3m^2 and each measuring 1.75 x 4.3m^2. Five ridges were made in each plot with 1 m as alley between the replicate and 0.5 m between plots. Spacing was 75 cm between rows and 25 cm within row.

2.5 Cultivation Practices

The first fallow was cleared with hand implements such as hoes and machete in order to keep the soil loose for good seedbed and subsequent effective germination and seedling emergence. Land was prepared manually in form of ridge of 4m long. Sowing was done in July at the full establishment of rainfall. Maize seeds were sown two per hole with inter-row and intra-row spacing of 75 cm and 25 cm respectively which was thinned to one per stand 2WAS. Weeding was done at 3 and 6 weeks after sowing (WAS). At three WAS, NPK 15:15:15 fertilizer was applied at the rate of 120 kg N, 60 kg P_2O_5 and 60 kg K_2O. A basal dose of 60 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 60 kg k_2O ha^{-1} was applied by side placement (5 cm away from the plant stand) at 3 WAS using a bottle cover (0.45kg) of NPK 15:15:15 as source.

2.6 Data Collection

Ten plant samples were randomly selected and measured from the ground level to the tip of the tallest leaf using a meter rule at 10WAS.

The diameter of the stem was measured by using Vernier calliper at 10WAS

Ear rot was rated on a scale of 1-5, where 1= little or no visible ear rot and 5 = extensive visible ear.

The number of days from planting to the time when 50% of the plants have tasselled shading polar were counted and recorded. The number of ear per plants was counted

Fresh weight was taken after harvesting of the plant using electronic weighing balance

Dry weight was taken after sun dried the maize using electronic weighing balance

The grain weight was done after the maize was threshing from the cob using electronic weighing balance

Infestation of Fall Armyworm on maize

Fall Armyworm severity was determined by scoring Armyworm damage to maize plant, using the following scale;

2.7 Data Analysis

The data collected were subjected to analysis of variance (ANOVA) using Statistical Analysis System (SAS) procedure version 9, 2002 model. The treatment means were separated using Duncan Multiple Range Test (DMRT) at 5% probability

Visual Rating Damage	Numerical Score	Resistant Reaction
No damage	0	likely escape
Few pin hole	1	Highly resistance
Few short holes on few leaves	2	Resistance
Several short holes (<50%)	3	Resistance
Several leaves with short holes (>50%)	4	Moderately resistance
Elongated lesion on a few leaves	5	Moderately resistance
Elongated lesions on several leave	6	Susceptible
Several leaves with long lesions or tattering	7	Susceptible
Sever tattering	8	highly susceptible
Plant drying as a result of foliar damage	9	Extremely sensitive to

Source: CIMMYT, (2011).

Table 1: Effect of Neem Leaf Extract on the Plant Height and Stem Diameter of Maize Varieties

Genotype	Plant Height (cm)	Stem Diameter (cm)
SAMMAZ 15	135.83^{b}	2.23^{a}
RIDO 9	150.17^{ab}	1.67^{a}
SAMMAZ 34	158.37^{a}	1.67^{a}
KAPAN 6	137.67^{ab}	1.70^{a}
OBA 98	154.23^{ab}	1.63^{a}
OBA SUPER 6	140.97^{ab}	1.77^{a}
SE±	5.753	0.18

Means followed by the same letter (s) in a factor column are not significantly different at 5 % level of probability using DMRT.

3. Results

Table 1 showed the plant height and stem diameter of selected maize.

There was significant difference ($p<0.05$) between SAMMAZ15 and SAMMAZ 34 recorded the highest plant height but not significantly different from other maize genotypes. On the other hand, there was no significant different among the maize genotypes tried for the experiment with respect to stem diameter despite that SAMMAZ 15 recorded the biggest stem diameter.

Some of plants cultivars were not infected by fall armyworm throughout the period of evaluation (Table 2). The cultivars were not significantly different at the first week after sowing (WAS). OBA 98 showed the highest rate of infestation by fall armyworm follow by SAMMAZ 15. Other genotypes showed minimum rate of infestation RIDO 9, OBA SUPER 6 whereas, SAMMAZ 36 and KAPAN 6 had the lowest rate of infestation by fall armyworm. At 2WAS the maize cultivars were significantly ($p<0.05$) different in rate of infestation which was the beginning of application of neem extract for control of fall armyworm (Table 2) SAMMAZ 15 having the highest rate of infestation followed by SAMMAZ 34, RIDO 9, OBA 98, KAPAN 6 while OBA SUPER 6 recorded the lowest rate of infestation by fall armyworm. At 3WAS, there was no significant difference among the genotypes. SAMMAZ 15 had the high reduction in the rate of infestation closely followed by SAMMAZ 34, RIDO 9, OBA 98, KAPAN 6 and OBA SUPER 6 showing the lowest reduction in the rate of fall armyworm infestation. Furthermore, at 4WAS, there were significant difference ($p<0.05$) among the maize genotypes with OBA SUPER 6 recorded the lowest significant incidence of fall armyworm compared to all other genotypes except SAMMAZ 34. SAMMAZ 34 also had significant lowest ($p<0.05$) infestation incidence compared to OBA 98.

Numbers of ear per plant was not significantly different among the maize cultivar genotypes. SAMMAZ 15 recorded significant difference ($p<0.05$) compared to OBA SUPER 6 and OBA 98 with OBA SUPER 6 having the lowest rotten ear but not significantly different from other maize genotypes. Whereas, the number of rotten ear per plant varied significantly ($p<0.05$) among the maize cultivar (Table 3) OBA 98 (1.93) as the highest rate of rotten ear which is closely followed by SAMMAZ 15, (1.80) KAPAN 6 (1.53), RIDO 9 (1.40) and SAMMAZ 34 (1.40) showing the same rate of rotten ear. The lowest rate of rotten ear was found in OBA SUPER 6 (1.13) (Table 3).

There was significant ($p<0.05$) difference in fresh cob weight, dry cob weight and grain yield. (Table 4). In the fresh cob weight SAMMAZ 34 has the highest fresh cob weight followed by OBA 98 while RIDO 9, SAMMAZ 15 and KAPAN 6. The lowest fresh cob weight was obtained from OBA SUPER 6. OBA 98 had highest ($p<0.05$) dry cob weight, followed by SAMMAZ 34, while OBA SUPER 6 recorded the lowest ($p<0.05$) dry cob weight, although not significantly different from RIDO 9. SAMMAZ 15, SAMMAZ 34 and OBA 98 recorded the highest grain yield but not significant from each other while OBA SUPER 6 showed the lowest ($p<0.05$) grain yield which was significantly different compared to RIDO 9 and KAPAN 6.

Table 2: Effect of Neem Leaf Extract on the Incidence of Fall Armyworm

GENOTYPE	1WAS	2WAS	3WAS	4WAS
SAMMAZ 15	19.20^{a}	21.45^{a}	13.87^{a}	14.03^{ab}
RIDO 9	17.03^{a}	18.50^{ab}	13.20^{a}	13.20^{ab}
SAMMAZ 34	16.38^{a}	18.77^{ab}	13.60^{a}	11.03^{bc}
KAPAN 6	16.38^{a}	15.40^{bc}	11.37^{a}	11.27^{abc}
OBA 98	19.60^{a}	17.40^{abc}	12.87^{a}	14.70^{a}
OBA SUPER 6	16.57^{a}	12.20^{c}	8.83^{a}	8.23^{c}
SE±	1.72	1.42	1.33	0.93

Means followed by the same letter (s) in a factor column are not significantly different at 5 % level of probability using DMRT.

Table 3: Effect of Neem Leaf Extract on the Number of Ear and Number of Rotten Ear of Maize plant

Number of Ear Per Plant and Number of Rotten Ear of Maize		
GENOTYPE	**Number of Ear Per Plant**	**(Scaled Rotten Ear)**
SAMMAZ 15	1.00^{a}	1.80^{a}
RIDO 9	1.00^{a}	1.40^{ab}
SAMMAZ 34	1.00^{a}	1.40^{ab}
KAPAN 6	1.00^{a}	1.53^{ab}
OBA 98	1.00^{a}	1.93^{a}
OBA SUPER 6	1.00^{a}	1.13^{b}
SE±	0.00	0.17

Means followed by the same letter (s) in a factor column are not significantly different at 5 % level of probability using DMRT.

Table 4: Effect of Neem Leaf Extract on Yield Parameters of Maize.

Yield Parameters of Maize			
GENOTYPE	**Fresh Cob Weight (kg)**	**Dry Cob Weight (kg)**	**Grain Yield Weight (tone/ha)**
RIDO 9	138.1^{c}	106.04^{c}	1.88^{b}
SAMMAZ 34	148.0^{a}	114.35^{b}	1.94^{a}
KAPAN 6	126.3^{e}	91.61^{e}	1.88^{b}
OBA 98	146.3^{b}	115.87^{a}	1.94^{a}
SAMMAZ 15	136.9^{d}	103.3^{d}	1.94^{a}
OBA SUPER 6	102.3f	73.47e	1.38c
SE±	3.745	3.537	0.094

Means followed by the same letter (s) in a factor column are not significantly different at 5 % level of probability using DMRT.

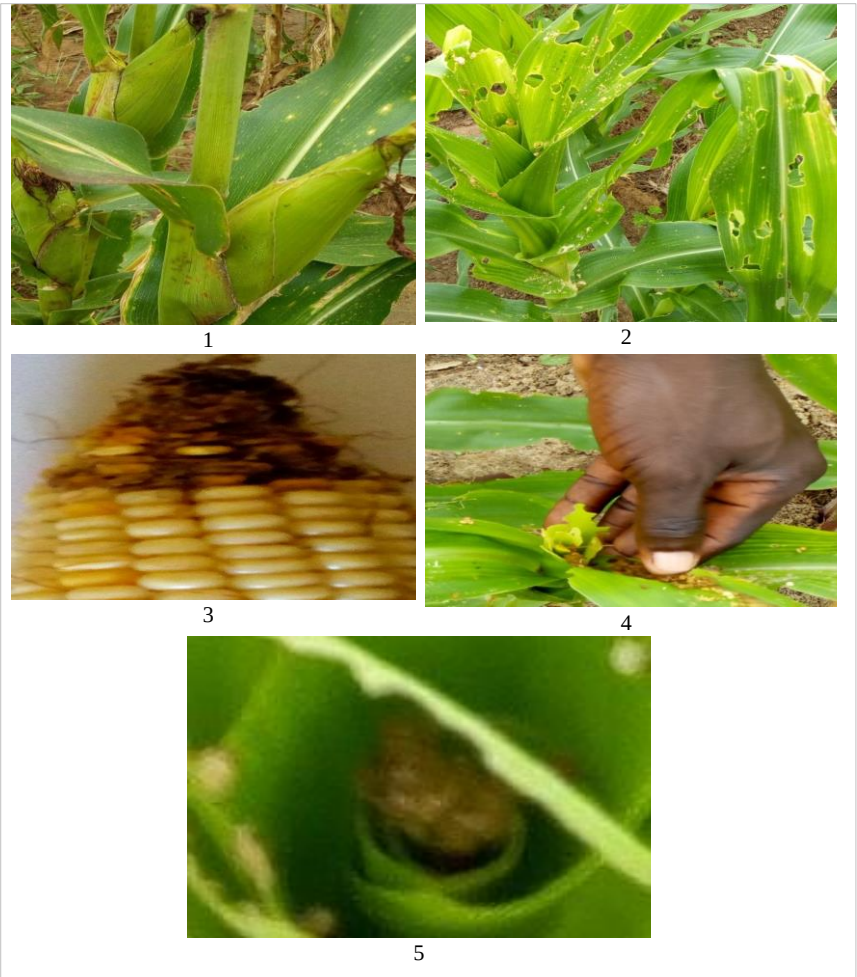

Plate 1: Multiple cob bearing in Oba98, **Plate 2**: infestation of fall armyworm on leaves of plant, **Plate 3**: effect of armyworm on cob damage, **Plate 4**: infestation of fall armyworm on whorl of plant, and **Plate 5**: armyworm eggs.

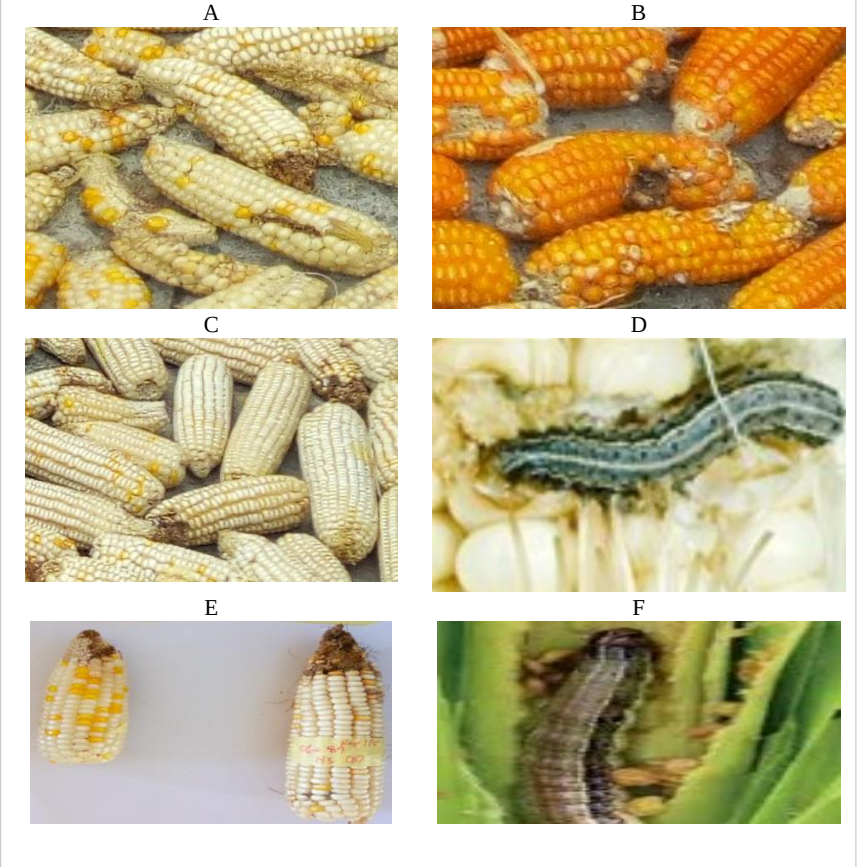

Plate 6: A= Sammaz15 with dead larvae, B= Rido9, C= Sammaz34, D= Kapan6, E and F = infestation on Oba super6.

4. Discussion

The fall armyworm *(Spodoptera frugiperda)* is a Lepidopteran pest that feeds in large numbers on leaves and stems of more than 80 plant species, causing major damage to maize, rice, sorghum, sugarcane but also other vegetable crops and cotton. The result obtained from this study indicated that the effect of Neem extracts varied among the six maize varieties in the control of fall armyworm on maize varieties. The plant height and stem diameter of the maize varieties varied with SAMMAZ 34 having the highest height (158.37 cm) followed by OBA 98(154.23 cm). Lowest height was recorded for SAMMAZ 15 (135.83 cm) but SAMMAZ 15was found to have the largest stem diameter (2.23 cm) followed by OBA SUPER 6 while the lowest stem diameter was seen in OBA 98 (1.63cm). This result confirmed the earlier model of Thornley (1998) that increase in stem diameter of infected plant will lead to decrease in the plant height while increase in plant height will result to decrease in stem diameter of the plant.

Some of maize varieties were not infested by fall armyworm throughout the period of evaluation. The result indicated that before the application of the neem extract the maize cultivars had already been infested by fall armyworm in the first week of sowing with SAMMAZ 15 showing the highest rate of infestation whereas SAMMAZ 36 and KAPAN 6 had the lowest rate of infestation. In the third week after sowing, the effect of neem extract to control fall armyworm on the maize genotypes was recorded. SAMMAZ 15 that had the highest rate of infestation in the second week after sowing had recorded drastic reduction of infestation with OBA SUPER 6 showing the lowest reduction in the rate of fall armyworm infestation.

Also, when considering the number of ear per plant of maize varieties infested by fall armyworm, all the maize varieties had almost the same number of ear per plant indicating that the fall armyworm had little effect on the number of ear per plant of the maize cultivar. Whereas, the number of rotten ear per plot differs among the maize cultivar with OBA 98 had highest rotten ear but the lowest rotten ear per plot was found in OBA SUPER 6. There are also differences in the yield parameter of Maize when considering fresh cob weight, dry cob weight and grain yield. For fresh cob weight, SAMMAZ 34 had the highest fresh cob weight (148.00 kg) while OBA SUPER 6 had the lowest fresh cob weight (102.30 kg). For dry cob weight, OBA 98 recorded highest dry cob weight (115.87 kg) while OBA SUPER 6 which showed the lowest fresh cob weight also showed the lowest dry cob weight (73.47 kg). For grain yield weight, SAMMAZ 34, SAMMAZ 15 and OBA 98 had the highest grain yield weight which agreed with study on the yield performance of maize treated with neem seed extracts against stem borers by Wahedi *et al.,* 2016 which confirmed that neem extracts were effective in protecting the maize plants from maize stem borers infestation, while OBA SUPER 6 which shows the lowest fresh cob weight, lowest dry cob weight still recorded the lowest grain yield weight.

5. Conclusion

From the result obtained above, it was concluded that OBA SUPER 6 had the lowest infestation and SAMAZ 15 had the highest infestation recorded. OBA 98 had the highest number of rotten ear while OBA SUPER 6 had the lowest. SAMMAZ 34 was recorded to have the tallest plant height while SAMMAZ 15 was recorded to have the shortest plant height. SAMMAZ 15 had the largest stem diameter while OBA 98 had the narrowest. SAMMAZ 15, SAMMAZ 34 and OBA 98 had the highest grain yield while 0BA SUPER 6 had the lowest grain yield.

Farmers could plant OBA SUPER 6 or KAPAN 6 maize variety to minimize the incidence of fall armyworm outbreak on the maize farm during rain-fed production. They could also cultivate SAMMAZ 15, SAMMAZ 34 and OBA 98 for grain yield.

Further studies should be conducted to validate the result obtained in this study or to clearly understand the mechanism of pesticidal effect of Neem leaf extract that was used for the management of fall armyworm in this study

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