



Yield Performances of Tomatoes (*Lycopersicon esculentum*) on Organic Manure Buffered Lateritic Soils

*¹LAMIDI, WA; ¹SHITTU, KA; ²ADEYEYE, AS

¹Department of Agronomy College of Agriculture, Ejigbo, Osun State University, Osogbo, Nigeria

²Department of Crop Production and Protection, Faculty of Agriculture and Life Sciences, Federal University, Wukari, Taraba State, Nigeria

*Correspondence Email Address: wasiu.agunbiade@uniosun.edu.ng

ABSTRACT: Lateritic soils are found in many farms even though they have not been known to be encouragingly productive to farmers because of their non-supportive of agricultural products. This experiment was to help farmers whose lands are lateritic to produce more crops/ha when buffered with organic manure. There were six treatments namely: laterite soil, laterite soil buffered with organic manure, laterite soil buffered with NPK 15-15-15, sandy loam soil, sandy loam soil buffered with organic manure (OM) and sandy loam soil buffered with NPK 15-15-15. There were three replicates for each treatments, the arrangement was 2 × 6 × 3 factorial design of 36 pots, parameters measured during the experiment were days to emergency, days to flowering, days to fruiting, number of branches, number of fruits per plant, nodes and internodes, stem girth length, leaf length of plant, plant height (from the surface of the soil to the apex (tip) of the plant) at twice a week and number of leaves per plant counted and recorded each week. The whole arrangements were subjected to the same environmental and climatic conditions. Chemical and physical characteristics of the soil in different treatments were done in the laboratory before and after. The data collected were subjected to two-way ANOVA. The results revealed that seed germination percentage was higher in sandy-loam buffered soil, 92.5%, followed by lateritic buffered soil 87.5%. Statistical analysis showed statistical differences among the yield and yield parameters for types of soil. However, the growth parameters taken as height, number of leaves, fresh and dry weight were found to be higher in sandy-loam soil followed by laterite soil and finally alluvium soil. Statistical analysis of these also showed significant differences between the types of soil used. Laterite buffered soil could yield as high as sandy loam soil in the production of tomatoes.

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Tomato plants typically grow to 1-3 metres in height and have a weak stem that often sprawls over the ground and vines over other plants. It is grown in both tropical and temperate climates; it does well in well-drained soil found some parts of Nigeria (Tindall, 1998). Although there is a considerable potential for increased tomato production, numerous factors limit yields (Mulatu and Lakew, 2011). The most important abiotic stresses include low soil fertility, low soil pH, poor soil drainage, drought and poor agronomic practices. The expansion of tomato production in Nigeria has been accomplished by the establishment of numerous vegetable processing industries, although the production level in the country is still far behind as most are consumed by buying raw from market. The establishment of both private and government network of dams and irrigation facilities, especially in Northern Nigeria have greatly enhanced the production of tomato in Nigeria (Quinn, 2003; Quinn, 1999). Poor soil fertility is a major constraint to agricultural productivity, where population and livestock pressure is high (Zelleke *et al.*, 2010; Agegnehu *et al.*, 2014a).

Chemical fertilizer application has been limited to date, and improvement of agricultural productivity necessitates more than the application of chemical fertilizers alone. Soil differs greatly in texture, chemical composition, colour, depending upon the particles size of mineral component and the amount of organic matter present. Laterite is a soil layer that is rich in iron oxide and derived from a wide variety of rocks weathering under strongly oxidizing and leaching conditions. It forms in tropical and subtropical regions where the climate is humid. Lateritic soils may contain clay minerals; but they tend to be silica-poor, for silica is leached out by waters passing through the soil. Typical laterite is porous and claylike. It is best used in road, buildings and dam constructions being product from rock that is a response to a set of physiochemical conditions. These conditions include an iron-containing parent rock, a well-drained terrain and abundant moisture for hydrolysis during weathering, relatively high oxidation potential, and persistence of these conditions over thousands of years. Lateritic soils are one of

*Correspondence Email Address: wasiu.agunbiade@uniosun.edu.ng

important soils and are widespread in tropical areas and subtropical climates. They are the most highly weathered soils in the classification system. The significant features of the lateritic soils are their unique color, poor fertility, and high clay content and lower cation exchange capacity. In addition, lateritic soils possess a great amount of iron and aluminum oxides (Shaw, 2001; Ko, 2008; Ko *et al.*, 2006). Parent material is a key factor affecting the iron and mineral composition and distribution for lateritic soils. Anda *et al.* (2008) reported a series of oxisols derived from serpentinite, basalt, and andesite and found that the content of iron oxides has an obvious different distribution.

Laterite is not uniquely identified with any particular parent rock, geologic age, single method of formation, climate *per se*, or geographic location. Since it can be found anywhere due to where it is produced from, it is good to be researched upon if it will readily support plant growth. Tomatoes, being delicate plant could be appropriate for such. There have been many options of agricultural systems that have been used in the area. Amelioration of subsoil horizons by using cover crops whose roots have the potential to drill into impermeable regions for nutrients' absorption (Chen and Well, 2010; Chen *et al.*, 2008), also known as biological drilling to create favorable soil structure for subsequent row crops to explore (Cresswell and Kirkegaard, 1995). This affects both macro- and micro-porosity depending on whether coarse or fine roots are involved (Bodner *et al.*, 2014). Also, inclusion of clover as a cover crop to enhance yield in a compacted sandy loam soil and the response was attributed to the effects of the organic mulch combined with root drilling (Stirzaker *et al.*, 1996). Lateritic soils are found in Ejigbo and environs especially in *Afaake, Isudurin, Ilawo* and its other adjoining villages. These lands may be made available and capable of to yield more per acre when buffered, thus the research was postulated. The research focused on the performances of lateritic soils when mixed with organic manure to be able to make the more available farmable land to the farmers in the area.

MATERIALS AND METHODS

Sample area and collection: This study was carried out in the Teaching and Research Farms of Osun State University, Ejigbo Campus, Osun State. The soils used were laterite and sandy loam, both soils were buffered and were also used as control. Buffering materials used were organic manure (OM) made from compost and inorganic fertilizers namely NPK 15-15-15 weighed at the rate of 4kg mixed thoroughly per soil sample in each pot (calculated from 200kg/ha rate for each of the pot as per its soil volume).

Sample preparation and treatment: There were six treatments namely: laterite soil, laterite soil buffered with organic manure, laterite soil buffered with NPK 15-15-15, sandy loam soil, sandy loam soil buffered with organic manure (OM) and sandy loam soil buffered with NPK 15-15-15. There were three replicates for each treatment, the arrangement was 2 × 6 × 3 factorial design of 36 pots. Tomato seeds were subjected to viability test to differentiate the viable seeds from non-viable seeds using floating method of transparent plastic container. This method of testing was 95-100% sure of the seed testing, although depending on the variety or type of seed to be cultivated. Weeding was not encouraged because the seedling could not be identified from the weeds. Sprouting of seedlings commence at different days and rate. Thinning was done to one stand per pot.

Soil Analysis: The soil analysis was conducted at the Agronomy Department Laboratory of Osun State University, College of Agriculture, Ejigbo to determine the mineral/heavy metals analysis of thirty six (36) soil samples. Soil samples were air dried at room temperature, pulverized and pass through the 2 mm sieve and analyzed using standard procedures. Samples were analyzed for physical and chemical properties for the following parameters: soil pH was determined in 1:1 soil water suspension using a pH meter (Hendershot *et al.*, 1993); Particle size distribution was determined by the Bouyoucos hydrometer method using Calgon as a dispersing agent (Gee and Or, 2002). Organic carbon was analyzed by the dichromate oxidation procedures of (Nelson and Sommers, 1996). Total Nitrogen was determined by micro-Kjeldah method (Bremner *et al.*, 1985); Available phosphorus was determined by Bray-1 method, (Anderson and Ingram, 1993); Exchangeable cations were determined extracted using NH₄OAc buffered at pH 7 (Thomas, 1982). Potassium (K) and Sodium (Na) were determined by a flame photometer while exchangeable Calcium (Ca) and Magnesium (Mg) were determined using Spectrophotometer (AAS) PerkinElmer 403.

Sample analysis: The following morphological parameters were measured during the experiment, days to emergency, days to flowering, days to fruiting, number of branches, number of fruits per plant, nodes and internodes, stem girth length, leaf length of plant, plant height (from the surface of the soil to the apex (tip) of the plant) at twice a week and number of leaves per plant counted and recorded each week. The whole arrangements were subjected to the same environmental and climatic conditions. Chemical and physical characteristics of the soil in different

treatments were done in the laboratory before and after the experiment to be able to deduce the change if at all in the soil with respect to the outcome of the yield parameters measured.

Statistical analysis: The data collected were subjected to two-way Analysis of Variance (ANOVA) using a statistical package by CoStat (CoHort Software, 2014). Mean values that were significant were separated using least significant difference.

RESULTS AND DISCUSSION

Seed germination: Sprouting commenced the second week of planting. Some germinated at five days while others germinated seven to eight days as shown with their mean values in Table 1. The first emergency of seedlings brings two cotyledon leaves and looks so small at fifth day for the first week. The results revealed that seed germination percentage was higher in sandy-loam buffered soil, 92.5%, followed by

lateritic buffered soil, 87.5%. They were all staked to prevent them from falling and for all the measured parameters to be appropriate. The plants carry different leave numbers and different leaf length.

Physical and chemical properties of the soil: The physico-chemical properties of soil before planting are presented in Table 1, it revealed low values of exchangeable cations, percent organic carbon (%OC) and OM, however there were slight changes after the buffering in either cases, Table 2. The increments were due to the buffering with OM and NPK. The soil reaction ranged between slightly acidic (6.91, Laterite non-buffered) and neutral (7.08, sandy loam buffered with OM (Adepetu *et al.*, 2014). The texture ranged between loamy sand to sandy loam. Cation exchange capacity (CEC) was generally low. The soil was deficient in major nutrients; therefore adequate soil amendment was necessary for profitable tomato crop production.

Table 1: Chemical and physical characteristics of different soils before the experiment

Soil Parameter	Soil types					
	Laterite non-buffered	Laterite buffered with OM	Laterite buffered with NPK	Sandy loam non-buffered	Sandy loam buffered with OM	Sandy loam buffered with NPK
Chemical characteristics						
pH (H ₂ O)	6.91	6.97	6.92	7.00	7.08	7.00
Organic carbon (%)	0.60	0.90	0.88	1.06	0.89	0.82
Organic matter (%)	0.20	0.82	0.40	0.98	0.99	0.70
Available P (ppm)	0.85	2.18	2.58	2.58	1.52	1.50
CEC, (meg/100g)	6.50	5.36	7.50	8.10	8.26	6.30
K (ppm)	40.21	50.47	50.23	46.08	92.12	40.15
Ca (ppm)	1.20	2.20	1.00	19.00	40.00	32.02
Mg (ppm)	8.20	10.80	11.40	16.40	35.40	29.80
Nitrogen(ppm)	0.13	0.18	0.37	0.28	0.72	0.52
Sodium (ppm)	20.12	30.23	27.30	38.58	42.33	32.50
Cu ²⁺ (ppm)	0.88	1.07	2.27	1.37	1.15	1.29
Mn ²⁺ (ppm)	9.12	11.23	60.21	29.59	99.37	80.50
Co ²⁺ (ppm)	0.75	1.20	1.20	1.38	0.20	4.21
Fe ²⁺ (ppm)	43.20	62.00	60.12	42.77	40.20	42.10
Zn ²⁺ (ppm)	0.91	1.42	1.20	1.77	3.40	1.92
Physical characteristics						
Sand (g/kg)	881.20	474.20	808.20	700.20	640.30	800.40
Silt (g/kg)	18.80	436.50	94.30	172.50	230.40	49.40
Clay (g/kg)	100.00	89.30	93.50	127.30	129.30	150.20
Textural class	Sandy clay	Sandy loam clay	Sandy clay	Sandy loam	Sandy loam	Silt loam

Yield and Yield parameters: The different treatments have significant effects at $p > 0.01$ and at $p > 0.05$ on the yield parameters of the tomatoes, plant height, number of leaves, leaf area, and number of buds produced, number of nodes and number of internodes produced per week. Others are on the stem girth, fruit weight, fresh fruit weight and number of tomato fruits produced, that is the eventual yield, Table 3.

However, there was no significant effect of the treatment on the tomatoes' fruit length and fruit breadth, that is, the perimeter of the tomatoes fruits. Coefficient of variation, CV reveals lower values in all, they were less than 30, implying the validity of the treatment and the overall design of the experiment. There were statistical differences among the mean values for yield parameters recorded in Table 4.

Table 2: Chemical and physical characteristics of different soils after the experiment

Soil Parameter	Soil types					
	Laterite non-buffered	Laterite buffered with OM	Laterite buffered with NPK	Sandy loam non-buffered	Sandy loam buffered with OM	Sandy loam buffered with NPK
Chemical characteristics						
pH (H ₂ O)	7.00	6.98	6.92	7.00	7.10	7.01
Organic carbon (%)	0.72	1.15	0.23	1.16	1.51	1.20
Organic matter (%)	0.65	0.92	0.07	1.18	1.24	1.20
Available P (ppm)	1.10	3.18	2.79	3.68	3.41	2.50
CEC, (meg/100g)	4.58	7.36	5.30	7.10	7.16	6.25
K (ppm)	80.00	93.57	75.23	96.07	110.10	90.20
Ca (ppm)	4.40	3.20	1.10	39.30	44.00	36.20
Mg (ppm)	20.40	13.50	13.40	26.10	35.40	30.20
Nitrogen (ppm)	0.09	0.23	0.37	0.33	0.73	0.50
Sodium (ppm)	22.50	35.53	47.80	36.53	52.33	40.50
Cu ²⁺ (ppm)	1.20	NA	2.27	2.37	2.13	1.12
Mn ²⁺ (ppm)	20.50	12.7	90.87	29.57	109.97	85.20
Co ²⁺ (ppm)	1.50	NA	NA	1.40	0.20	0.20
Fe ²⁺ (ppm)	60.2	81.53	80.20	72.07	80.20	70.20
Zn ²⁺ (ppm)	1.20	2.30	2.93	2.77	4.43	2.80
Physical characteristics						
Sand (g/kg)	430.50	430.50	812.10	704.20	642.20	600.50
Silt (g/kg)	500.20	480.20	92.30	170.40	236.40	199.10
Clay (g/kg)	69.30	90.30	95.60	125.40	121.50	200.40
Textural class	Sandy clay	Sandy loam clay	Sandy clay	Sandy loam	Sandy silt loam	Sandy silt loam

Table 3: Analysis of variance table on tomato

Yield parameters	ANOVA analysis						CV%
	Block	Soil type	Treatment (Trt)	Soil type × Trt	Error	Total	
Degree of freedom	2	2	2	4	16	26	
Plant height, cm	1073.76*	43.01 ^{ns}	63.93 ^{ns}	24.46 ^{ns}	26.60 ^{ns}		11.27
No. of leaves	520.78*	30.33 ^{ns}	10.33 ^{ns}	31.33 ^{ns}	26.40 ^{ns}		5.45
Leaf area, m ²	99.20*	9.54 ^{ns}	0.31 ^{ns}	6.69 ^{ns}	4.89 ^{ns}		25.40
No. of buds	6.37*	3.70 ^{ns}	2.93 ^{ns}	0.48 ^{ns}	1.54 ^{ns}		4.19
No. of nodes	16.33*	0.78 ^{ns}	0.11 ^{ns}	0.89 ^{ns}	0.92 ^{ns}		4.54
No. of internodes	1.22*	0.18 ^{ns}	0.16 ^{ns}	0.03 ^{ns}	0.16 ^{ns}		6.60
Stem girth, cm	1.82*	0.08 ^{ns}	0.08 ^{ns}	0.22 ^{ns}	0.16 ^{ns}		6.81
Fruit length, cm	2.37 ^{ns}	1.41 ^{ns}	2.83 ^{ns}	0.32 ^{ns}	1.01 ^{ns}		19.89
Fruit breadth, cm	5.52 ^{ns}	0.62 ^{ns}	3.41 ^{ns}	3.39 ^{ns}	2.96 ^{ns}		20.53
Fruit weight, g	6.27*	0.14 ^{ns}	0.29 ^{ns}	0.21 ^{ns}	0.24 ^{ns}		19.93
Fresh fruit weight, g	15.41*	1.28 ^{ns}	1.94 ^{ns}	1.88 ^{ns}	2.27 ^{ns}		25.94
No. of fruits	14.40*	0.19 ^{ns}	0.38 ^{ns}	1.17 ^{ns}	1.05 ^{ns}		23.18

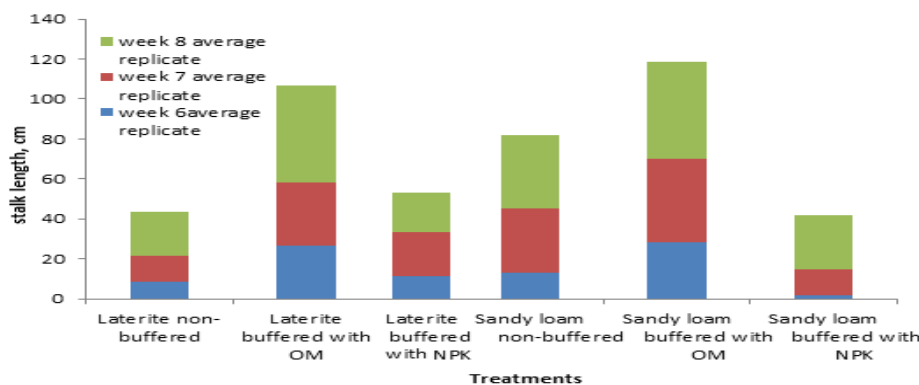
* - significant at $p \geq 0.05$, ** - Highly significant $p \geq 0.01$, CV (%) - coefficient of variation**Table 4:** Mean values of the yield parameters depicting effects of different treatments on tomato

Yield parameters	Soil samples	Laterite buffered with OM	Laterite buffered with NPK	Sandy loam non-buffered	Sandy loam buffered with OM	Sandy loam buffered with NPK
Plant height, cm	43.66 ^c ± 2.77	44.90 ^{ab} ± 3.61	47.40 ^b ± 2.65	43.29 ^c ± 4.37	46.60 ^a ± 3.83	48.77 ^a ± 4.19
No. of leaves	93.78 ^c ± 2.49	95.44 ^a ± 2.76	95.44 ^a ± 2.41	96.11 ^a ± 3.60	92.11 ± 1.89	93.44 ^c ± 3.02
Leaf area, m ²	8.85 ^b ± 1.82	8.49 ^b ± 1.17	9.12 ^a ± 1.16	9.46 ^a ± 1.44	7.53 ^c ± 0.89	8.77 ^b ± 1.31
No. of buds	30.22 ^a ± 0.22	29.11 ^{ab} ± 0.54	30.33 ^a ± 0.33	29.22 ^{ab} ± 0.59	29.22 ^b ± 0.40	29.44 ^c ± 0.56
No. of nodes	21.11 ^{ab} ± 0.26	21.00 ^{ab} ± 0.55	21.22 ^b ± 0.40	20.78 ^c ± 0.64	21.33 ^a ± 3.33	21.22 ^b ± 0.59
No. of internodes	5.94 ^b ± 0.23	6.20 ^a ± 0.11	6.17 ^{ab} ± 0.12	5.89 ^{ab} ± 0.15	6.09 ^a ± 0.19	6.00 ^{ab} ± 0.10
Stem girth, cm	5.79 ^{ab} ± 0.22	5.73 ^{ab} ± 0.15	5.77 ^{ab} ± 0.16	5.92 ^a ± 0.18	5.76 ^{ab} ± 0.21	5.92 ^a ± 0.17
Fruit length, cm	6.15 ^a ± 0.47	4.91 ^c ± 0.11	4.91 ^c ± 0.16	5.19 ^{ab} ± 0.15	5.10 ^{ab} ± 0.12	5.19 ^{ab} ± 0.13
Fruit breadth, cm	9.55 ^a ± 0.54	8.34 ^{ab} ± 0.18	8.36 ^{ab} ± 0.24	8.35 ^{ab} ± 0.26	8.42 ^{ab} ± 0.21	8.31 ^{ab} ± 0.22
Fruit weight, g	2.80 ^a ± 0.00	2.36 ^{ab} ± 0.22	2.48 ^{ab} ± 0.29	2.55 ^c ± 0.31	2.36 ^{ab} ± 0.29	2.60 ^c ± 0.28
Fresh fruit weight, g	5.26 ^a ± 0.00	4.22 ^{ab} ± 0.31	4.94 ^c ± 0.44	4.43 ^{ab} ± 0.63	4.32 ^{ab} ± 0.46	4.64 ^c ± 0.59
No. of fruits	6.00 ^{ab} ± 0.00	5.75 ^{ab} ± 0.41	6.11 ^b ± 0.54	6.56 ^a ± 0.69	5.78 ^b ± 0.64	5.90 ^c ± 0.71

Mean values with the same letter(s) along the row are statistically different at $p > 0.01$ and 0.05

Table 5: Mean values of the fruiting and fruit parameters depicting effects of different treatments

Yield parameters	Soil samples					
	Laterite non-buffered	Laterite buffered with OM	Laterite buffered with NPK	Sandy loam non-buffered	Sandy loam buffered with OM	Sandy loam buffered with NPK
No. of days to emergency	6.93 ^a ±0.22	6.13 ^{ab} ±0.12	6.72 ^b ± 0.2	6.97 ^b ±0.19	5.20 ^c ±0.22	6.20 ^{ab} ±0.53
No. of Stalk lodged	8.41 ^b ±2.33	11.16 ^a ±2.53	8.81 ^b ±3.28	7.90 ^{ab} ±1.39	6.84 ^c ±1.81	7.86 ^{ab} ±2.06
Days to flowering	46.43 ^{ab} ±0.35	42.77 ^b ±2.5	40.67 ^c ±6.09	51.20 ^a ±6.54	47.20 ^{ab} ±8.89	41.50 ^c ±5.18
No. of flowers	21.33 ^{ab} ±1.76	20.33 ^{ab} ±1.20	20.67 ^{ab} ±0.33	21.67 ^a ±0.33	21.00 ^{ab} ±1.15	21.33 ^c ±0.33
No of Flower aborted	5.12 ^{ab} ±0.15	5.61 ^a ±0.47	5.56 ^{ab} ± 0.34	5.00 ^c ± 0.13	5.00 ^c ± 0.20	5.00 ^c ± 0.02
No of Fruit aborted	8.37 ^a ±0.27	8.20 ^{ab} ±0.82	7.20 ^c ±0.82	8.47 ^a ±0.43	8.42 ^a ±0.25	8.20 ^{ab} ±0.82
No. of days to ripening	6.03 ^a ±0.27	5.93 ^b ±0.27	5.80 ^{ab} ±0.46	5.97 ^a ±0.39	5.33 ^c ±0.07	5.97 ^a ±0.48
Fresh Fruit weight, kg	93.67 ^{ab} ±5.67	97.10 ^a ±8.33	94.67 ^c ±7.17	88.00 ^c ±1.15	94.67 ^a ±3.84	93.67 ^{ab} ±3.71
Fruit weight, kg	29.00 ^{ab} ±1.53	28.67 ^b ±1.20	30.00 ^a ±0.00	29.33 ^{ab} ±0.88	28.33 ^c ± 0.33	30.00 ^a ±0.58
No. of days to rotting	5.93 ^b ±0.23	6.03 ^{ab} ±0.17	5.70 ^c ± 0.42	5.97 ^{ab} ±0.19	6.20 ^a ±0.20	6.10 ^a ±0.59

**Fig 1:** Chart showing growth of vegetative stalk at critical 6th, 7th and 8th weeks

Therefore the effect of the buffering with OM and NPK were on the crop as their yield parameters were significantly influenced, Table 4. In all, OM had higher values than NPK in both soil types. The effect of the buffering was also revealed when the non-buffered mean values of the yield parameters and those buffered were compared, Table 4.

The various treatment applied as well as the various soil conditions significantly differed on all the growth parameters after monitoring for 4, 5 and 6 weeks after planting (WAP).

Similarly, the number of flowers per plant and the total fresh fruit were significantly affected by the soil type and both buffering materials.

Fruit and fruiting parameters: Numbers of flowers per plant of tomato were significantly influenced also by the various treatments across successive replicate, Table 5, Figure 1. Significantly, higher number of flowers were recorded from plants treated with OM and NPK 15:15:15. While the least number of flowers per plant were experienced in the sandy loam soil.

Conclusion: Lateritic soil if buffered with organic matter could yield as high as the sandy loam soil for the planting of tomatoes. The same lateritic soil when

buffered with NPK may not yield more crop per hectare of land when compared to organic matter buffering.

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