Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 22, Issue 4, 2022
PRINT ISSN 2284-7995, E-ISSN 2285-3952

EFFECT OF ORGANIC AMENDMENTS ON THE VEGETATIVE DEVELOPMENT OF OKRA (*ABELMOSCHUS ESCULENTUS* L. *MOENCH*) AT DIFFERENT WIND'S DIRECTIONS

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Abstract

Three different heights of prevailing wind: 0 m, 1 m and 2 m and two organic treatments (poultry manure, PM and rice bran, RB) were used. Organic treatments were divided into eight, namely 5 tons/ha RB (RB5), 10 tons/ha RB (RB10), 5 tons/ha PM (PM5), 10 tons/ha PM (PM10), 5 tons/ha each of RB and PM (RB5PM5); 10 tons/ha RB and 5 tons/ha PM (RB10PM5); 5 tons/ha RB and 10 tons/ha PM (RB5PM10), 10 tons/ha RB and 10 tons/ha PM (RB10PM10) at 3 × 2 × 6 × 3 factorial with control experiment. Measured were plant height, number of leaves, number of branches, stem girth. Results revealed that RB5PM10 yielded tallest plant (27.5 ± 8.15 cm), high number of leaves (15.75); highest leaf area (397.50 ± 18.22 cm^2); stem girth (1.70 ± 6.25 cm), all at 1 m wind height, respectively translating to 48.64, 0.01, 47.22 and 21.43% more than their corresponding values in control experiment. Application of RB and PM in ratio 1:2 respectively to soil enhanced all yield components and vegetative development provided heights of okra are maintained at 1 m from soil surface for winds' effectiveness.

Key words*: *growth, heights, poultry manure, rice bran, yield

INTRODUCTION

The tender green pods of okra (*Abelmoschus esculentus* L) are important sources of vitamins: A, B1, B3, B6, C and K, folic acid, potassium, magnesium, calcium and trace elements such as copper, manganese, iron, zinc, nickel, and iodine [4]. These properties are often lacking in the diet of people in most developing countries. The fruit also contains 86.1% moisture, 9.7% carbohydrate, 2.2% protein, 0.2% fat, 1.0% fiber and 0.8% ash [6]. The tender fruits are also popular for their medicinal values as they contain very high levels of antioxidants including xanthin, and lutein [19]. It also helps in stabilizing blood sugar levels and assists in controlling the rate at which the sugar is absorbed in the body. Okra is important soup delicacy because of its nutritive values that are present in the leaves and fruits [2]. Okra as a soup is a delicious lubricant for "swallows" Swallows are solid food made from *gari*, yam flour, cassava flour, pounded yam or cassava (*fufu*) and of recent grounded maize mix with flour called semo-vita. Some people among Yoruba ethnic nation like soup of tender okra leaves than its soup made from its fruits and that is why boosting its production is not out of line.

A well – drained sandy loam soil with a pH range of 6.0 - 6.8 is preferred for the cultivation of okra. Many research works have revealed that okra performs excellently well when organic manure is applied. [20] demonstrated an excellent use of pig slurry to improve chemical properties of degraded soil and plant nutrient uptake (nutrient plant uptake). In the face of current global warming, there is a need for improving on better production techniques toward crop yield increment. These may be in the climatic modifications/integration at the crop surfaces and especially temperatures and humidities control at crops' surface through wind's movements at different heights.

Wind has been known to affect crops in several ways both at lower and higher velocities [5, 1]. Generally it was found that long exposure to strong winds causes morphological changes, hot wind may results in dwarfing due to desiccation of plant tissue and reduced growth [1]. Many physiological processes, from the emergence of seedlings to fruit development and maturity depend on the quantity and quality of the light and wind that crops were exposed [7]. Application of shading net is one of the important factors that greatly influence the growth and yield of okra [10]. Some of the questions that this research work will answer are; would there be any yield difference when various avenues of wind exposures to crops in term of wind's height to the soil surface are applied. Would wind's movements near crop's surfaces if it is really worked on, may positively affect temperature and humidity near crop leaves and may increase their vegetative productivities.

Previous works have also been carried out on the study of light intensity on the photo regulation of plant [22, 9, 11], but very little work has been done on wind speeds and directions on the growth or physiology of okra and most especially in combination with different organic amendments. It has therefore become necessary to develop alternative ways to boost okra production under different planting orientation to the prevailing wind's direction as a means of contributing to boosting food supply especially as global warming is now a threat to food security in the world. Hence, this research work evaluated the vegetative growth of okra by analyzing variation patterns and relationships among the ratio of nutrient source using qualitative characters when crops are exposed naturally to differing wind's speeds at different heights from the ground surface.

MATERIALS AND METHODS

The field experiment was conducted at the Teaching and Research Farms of the College of Agriculture, Osun State University, (Latitude 7^{o}, 52'28.37"N and Longitude 4^{o}, 18'13.76"E) Ejigbo campus from late May to August, 2019. The climate is typically rain forest type with two peaks of rain (bimodal rainfall) which is between 1,158 mm-1,250 mm per annum. The temperature regime is high all the year round with mean of 28 °C-33°C, relative humidity of about 85%, except during dry season and sunshine of 5.1%. The soil samples were collected from different spots at a depth of 0-30 cm using a ziz-zag method and analysed at the Agronomy Laboratory of Osun State University, College of Agriculture. They were bulked together to form a composite soil sample for pre-planting soil analysis. The soil was air dried and sieved using 2 mm sieve, it was then analysed for both physical and chemical properties. Two organic treatments (rice bran, RB poultry manure, PM) and three different heights of prevailing wind movements (0 m, 1 m, and 2 m) were used in the research. The reason for using these 3 different heights of wind was because okra grows from 0 m height to between 1 and 2 m heights. Although some varieties may grow than 2 m, such variety was not popular in the Nigeria. Complementing this is the fact that vegetativeness was the focus of the research and not the okra seeds. The organic nutrient sources were applied to the field 30 days before seeds were sowed. These nutrients were allowed on the field for 30 days to synthesize naturally with the soil for its nutrients to be mineralized and become available and useful to the crops. Organic treatments were divided into eight: 5 tons/ha rice bran (RB5), 10 tons/ha of rice bran (RB10), 5 tons/ha poultry manure (PM5), 10 tons/ha poultry manure (PM10), 5 tons/ha each of rice bran and poultry manure (RB5PM5), 10 tons/ha rice bran and 5 tons/ha poultry manure (RB10PM5), 5 tons/ha rice bran and 10 tons/ha poultry manure (RB5PM10) and 10 tons/ha rice bran and 10 tons/ha poultry manure (RB10PM10). The okra variety, West African okra popularly called lady finger, was planted in May 2019 and vegetatively harvested in June 2019, a period of 42 days, (7 weeks). Spacing was 90 cm between the rows and 20 cm apart along the furrow, depth of planting was 1 inch deep.

There was a control experiment with zero organic amendment applied. The design was 3 × 2 × 6 factorial (3 different heights of winds from the ground surface, 2 organic amendments and 6 treatments). Each of these treatments was replicated three times, that is, 3 × 2 × 6 × 3 totaling 108. Temperature, humidity, wind speeds and directions were taken at 10.00 h and 14.00 h daily using field digital thermometer (model SW-1189, made by Uniscope, Nigeria Ltd) to measure temperatures and using hygrometer model M50.60101, 023460 made in France to measure humidity. The values for wind parameters at different heights were collected from School meteorological unit. The temperature-humidity index (THI) values were computed. THI values results from combination of temperature and humidity as a degree of measure of comfort/discomfort experience by animal or crops were computed from temperature and humidity values using THI equation [14]:

$$THI = t_{db}-[0.31(1-\frac{RH}{100})(t_{db}-14.4)] \text{ in } ^oC$$

where:
THI = Temperature-Humidity Index
t_{db} = dry bulb temperature, ^oC
RH = relative humidity, %.

Moreover, other parameters measured were plant height using tape rule, number of leaves, and number of branches by direct counting of their number and stem girth was measured using vernier calipers. Also measured were vein length using tape rule and leaf area index. The leafy yields of okra were measured using standardized weighing scale.

The characteristics of the soil, the poultry manure and the rice bran used for the study are shown in Tables 1 and 2. The result of the chemical properties of the soil and their particle size analysis shows that the soil texture was sandy loam. Table 1 reveals that the soil is weakly acidic, this informs the low quantity (quality) of the cations in the soil and in its organic matter. With that low quantity of cations, there could be low cation exchange capacity of ions in the soil [18]. The bulk density value as shown is moderately good for the crop as well as the proportional quantity of soil particles in the soil. As shown in Table 1, the soil fertility was inherently low, based to the nutrients rating for soil fertility classes in Nigeria [15, 17] and this implies that cropping the soil without the use of soil amendments will affect the yield. However, organic carbon, nitrogen and the available P for poultry manure were higher than the corresponding values for soil, showing higher potential fertility inherent in it than the soil. Thus, it is capable of being used as amendment. Also, Table 2 reveals the proximate values from [21] for the rice bran, the higher ash content, 13.28 ± 0.26, could be able to add more nutrients to the soil which may adduced to the fact that the rice bran is not a bad choice to be used as soil amendment.

Statistical Analysis

Table 1. Physico-chemical properties of the soil and poultry manure

PARAMETERS	Soil	Poultry manure/100mg
Chemical properties		
pH (H_2O)	6.40	9.25
Organic Carbon (%)	0.52	6.76
Total N (%)	0.41	0.59
Available P (mg/kg)	16.7	
Na^+(Cmol/kg)	0.18	0.47
K^+(Cmol/kg)	1.22	0.55
Ca^{2+}(Cmol/kg)	1.22	0.31
Mg^{2+}(Cmol/kg)	0.69	0.33
Organic matter (%)		11.49
Cu^{2+}		0.003
Fe^{2+}		0.57
Mn^{2+}		0.12
Zn^{2+}		0.03
Bulk density (g/cm^3)	1.2	
Moisture content		75.44
Particle size analysis		
Silt (%)	25.00	
Clay (%)	15.00	
Sand (%)	60.00	
Textural Class	Sandy loam	

Source: Primary data got from Laboratory analysis of soil and poultry samples', College of Agriculture, Osun State University, Nigeria.

Table 2. Chemical (Proximate) properties of rice bran

Component (%)	Conventional rice bran
Moisture content	9.99 ± 0.09
Crude Protein	11.01 ± 0.15
Crude Fat	15.17 ± 0.20
Crude fibre	16.47 ± 0.64
Ash	13.28 ± 0.26
Carbonhydrate	34.08 ± 1.22
Reducing sugar	6.13 ± 0.14

Source: [21].

The characters were subjected to analysis of variance using SPSS 16 and the means were

Scientific Papers Series Management, Economic Engineering in Agriculture and Rural Development
Vol. 22, Issue 4, 2022
PRINT ISSN 2284-7995, E-ISSN 2285-3952

separated using DMRT at 5% level of significance.

RESULTS AND DISCUSSIONS

There was general increase in the number of leaves of okra during the formative weeks; this is expected as its foliage develops just like any other plant in that period [8]. However, there are differences in the level of foliage development as shown in Figure 1.

The general increase in the number of leaves of okra during the formative weeks are depicted in the differences within the level of foliage development, Figure 1, this could be from wind factors, which could have influenced other climatic factors or soil factors. In all, there were increase in vegetative growth, this further confirmed the report of [8] that nutrient's availability especially nitrogen determines plant vegetative grow.

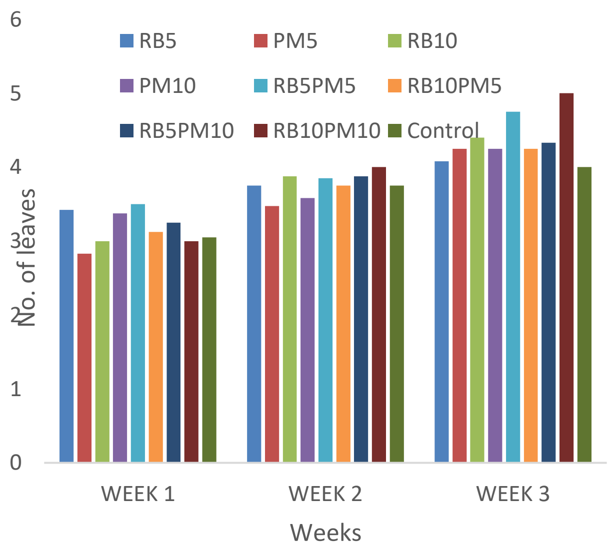

Fig.1. Average number of leaves during formative period of okra at different treatments

Source: Primary data gotten from field that was subjected to statistical analysis and latter expressed in Fig. 1.

Since some soil factors are the same for all the treatments, these differences depicted in the within the level of foliage development could be as a result of differences in the organic media contents in the treatments. Also, the differences could be as a result of differing wind speeds at different heights which could have led to variations in the temperature and humidity values recorded from the experimental field spots.

The temperature-humidity index, THI values as shown in Table 4 revealed varying values at different heights of wind from soil surface and weeks after planting (WAP) and growing. All the THI values were between the range 29.77 and 35.31 ^{o}C. The temperature and humidity values where these THI values were computed from (using THI equation above), were within the acceptable range of 25 ^{o}C-29 ^{o}C and 67-80% respectively, they are within the range of the comfort zone for crops [14] in the tropics and therefore suitable for the okra.

There were statistical differences in the mean values for some yield components of okra namely plant height, leaf area index and in the stem girth shown in Table 3 among all the treatments and there are fluctuating weekly yield components' values as shown in Figures 1-2. This shows variations in the level of developments of each of the parameters as they contribute to the yield of the okra vegetatively. These results reveal evidence that the crops could have had interrupted comfortability during the period under consideration. Thus, their physiological processes could have been affected by the wind's speed or its prevailing direction in all the heights of wind's movements considered. This could have led to the resulted statistical differences in the mean values for some yield components of okra namely plant height, leaf area index and in the stem girth as shown in Table 3, although, the Least Significant Differences (LSD) values were low in both Table 3, this implying close mean values that were not too different.

The fluctuations recorded in weekly yield components' values in Figs. 1-2 could be surmised to have come from climatic factors namely winds' movements and possibly direction, temperatures and humidities and THI, just like how the heights of the wind movement to the ground surface could have resulted in different THI values, Table 3.

As a result of moderate THI values (30.00-34.74 ^{o}C) in Table 4 and the wind movements as shown in their wind speeds' recorded (<10<50 km/h) at all different heights from the ground surface, Table 4, there were evident influences of all of these on okra. The highest LAI value in the RB5PM10 combination of rice bran and poultry manure in the mixing ratio 1:2 gave the highest vegetative stance (LAI = 397.50± 18.22 mm) for okra as shown in Table 3. This results also revealed that organic manure especially poultry manure could increase crops' height when combined with other source of manures. Thus proving that adding organic nutrients to the soil is good because it will act as a store house for cations with high exchangeable capacity and as a buffering agent against undesirable pH fluctuations [15]. This could be confirmed with the control experiment as it was observed that treatment without manure (control) did not do well compare to other treatments, even though, all of them were subjected to the same environmental conditions. The poor development of vegetative characters could happen if other factors like wind effects, and their resulting change in climatic factors near the crop's surface came as turbulence especially if the wind speeds are more than 50 km/h near the crops' surface [13].

Table 3. Mean characteristic performance of each treatment on Okra

S/N	Treatments	Plant Height, cm	Leaf Area Index, cm^2	Stem Girth, cm
1	Control	18.50±10.20 bc	270.00±12.22 c	1.40±11.20 bc
2	RB5	19.13 ± 7.13 c	323.50±11.12 b	3.10 ± 8.32 a
3	RB10	20.78 ± 2.14 c	326.21±21.23 b	2.10 ± 2.20 b
4	PM5	22.00 ± 9.12 b	336.93±12.11 b	1.70 ± 11.82 c
5	PM10	24.13±3.10 ab	354.18±21.20 ab	1.80 ± 2.22 ab
6	RB5PM5	19.38 ± 2.16 c	303.78± 22.01 bc	1.70 ± 10.24 c
7	RB10PM5	22.63 ± 6.11 b	311.59± 11.20 bc	1.70 ± 8.20 c
8	RB5PM10	27.50 ± 8.15 a	397.50± 18.22 a	1.70 ± 6.25 c
9	RB10PM10	20.00 ± 2.10 c	363.69.±12.02 ab	2.00 ± 12.00 a
	LSD	10.38	5.87	3.80

[ab]= Means in the same column followed by the same letter(s) are not significantly different at $p \leq 0.05$ by DMRT

Source: Primary data gotten from the field that was subjected to statistical analysis and latter expressed in Table 3.

RB5PM10 yielded tallest plant (27.50 ± 8.15 cm), though with low number of leaves (15.42 at week 7, Fig. 2) compare to RB10PM5, 16.42 and RB10PM10, 15.75, but also with maximum vegetative growth and leaf area (397.50 ± 18.22 cm^2) and stem girth 1.70 ± 6.25 cm, all at 1 m wind height. These translated to 48.64, 0.01, 47.22 and 21.43% more than their corresponding values in control experiment.

Table 4. THI (in degree centigrade) values at different heights of wind movement from the ground for all treatments

Weeks	THI ºC at different heights of wind movements from the ground surface		
	0 m	1 m	2 m
1	34.42	34.44	34.74
2	35.31	33.56	33.10
3	31.31	32.07	32.85
4	30.44	29.77	30.92
5	31.61	31.03	30.75
6	30.80	30.97	31.79
7	32.04	31.17	31.33

Source: Primary data gotten from the field that was subjected to statistical analysis and latter expressed in Table 4.

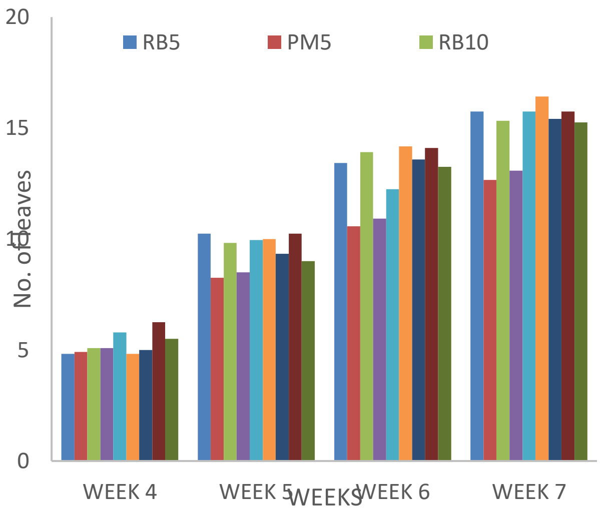

Fig. 2. Average number of leaves during maturing period of okra at different treatments

Source: Primary data gotten from the field that was subjected to statistical analysis and latter expressed in Fig. 2.

There were linear increases in growth parameters and yield components from 0 m to 1 m and to 2 m wind heights, Figure 2. All these could be the reason why combination of rice bran and poultry manure gave the highest vegetative stance for okra as in the increase in number of leaves per plant and plant stem girth with organic fertilizer application. This stresses the importance of adding organic media during the vegetative growth of plants.

The computed THI values from air temperature and humidity are shown in Table 4. The wind speeds were lower than 50 km/h. These values of wind speed were always at EW direction in more than 75% of the days/times when they were measured. From Table 5, the standard deviation values are very low depicting that the wind speed values are close in values (LSD also attests to this), thus the wind movement within the period was moderately low and apparently uniform. There were also statistical differences among the wind speed values signifying differences as a result of the heights of the wind from the ground at the time 10.00h and 14.00h during measurements.

Table 5. Weekly mean values of wind speed at 0, 1 and 2 m wind's height

Weeks	Wind speed at different heights from ground surface, km/h		
	0 m	1 m	2 m
1	6.02 ± 2.12c	6.21 ± 1.62c	7.07 ±1.00c
2	7.02 ± 1.19a	6.82 ± 2.00c	8.66 ±2.24a
3	6.73 ± 2.04ab	8.10 ± 1.01a	7.42 ±2.70b
4	6.21 ± 1.58b	8.09 ± 1.60a	7.30 ±1.47b
5	6.11 ± 1.07b	7.00 ± 2.00ab	8.00 ±1.86ab
6	6.22 ± 1.21b	6.87 ± 2.13c	7.09 ±1.72c
7	7.31 ± 1.75a	8.77 ±1.43a	7.10 ±1.07c
LSD	5.22	6.34	8.77

Note: Wind direction = EW

Source: Primary data gotten from the field that was subjected to statistical analysis and latter expressed in Table 5.

These differences could be the same reason why yield parameters in Table 3 were statistically different. The Least Significant Differences (LSD) values were low in both Table 5 implying close mean values that were not too different and infer that the difference between the wind speeds at various levels tested were significant.

Although the okra planted were not wind-induced, yet wind directly affects their growth rates and hence leafy yields and therefore could have resulted into statistical differences among the yield components of okra. Also, moderate wind resulted from combined effects from THI values in Table 4 could have directly affected okra's growth rates and hence leafy yields in the sense that wind's carrying lower THI values as depicted in computed THI in Table 4 were warm, (maximum THI = 34.74). since warm air does not cause turbulence but calmness, then this could further be explained as resulting calm to moderate wind. This favours dew deposition needed under condition of soil moisture stress and could have helped the plants to grow positively [1].

This is evidence from Table 5, the low standard deviation values depict that the wind speed values although not too different but infer that the wind movement within the period was moderately low, apparently uniform and non- turbulent, although, there was turbulent mixing, but it was of normal and balance mixing that are apparently tolerable to crops' comfort [3, 16], because the crops were still able to do well (Table 3). Also, at different heights from the ground surface, the wind speeds as shown are differently lower in values for each of the height, this that the winds was not turbulent throughout and could have been responsible for the low THI computed from low temperatures and humidity values, Table 4- these low THI values are positive to induce good leafy growth in the okra [12, 14]. Furthermore, it was because the wind speeds were low than 50 km/h, which if it was more could have caused lodging of okra plant and dilapidated leaves from the wind turbulence [12, 13]. And since this was not so, due to the low values of the wind speed, the crops could be adjudged to be comfortable at those temperatures, humidities and the THI(s) since there were no stalking nor lodging of okra plant and dilapidated leaves.

Then with the reduction in wind, less turbulent mixing could have occurred near the okra leaves' surfaces. Turbulent mixing is the process which happens during the day when warm air from the surface rises and is replaced by the cooler air aloft [16, 22] and since this occurred moderately on the crop surface (as evident in the non-stalking, non-lodging okra leaves), injury were not caused to the okra leaves. This was evident in the leaves that were neither broken nor dilapidated during the experiment. Based on above therefore, it could be adjudged that the wind speed, as it was, reduced near the okra leaves at 1 m, this could signify the quiet/calm zone near the okra leaves. The effect of reducing the amount of turbulent mixing involved will allow air temperatures near the surface to decrease and this decrease reflected in the computation of the THI values (Table 4). But this increase was not significant enough to cause problem. In contrast, this increase could possibly hasten the development of a crop as observed by [22] in their experiment in the desert region of Nigeria. It could also be that because of the reduced turbulence mixing in air on the okra leaves surfaces that made the number of leaves more favourable in the experiment as shown in Figures 1 - 2. This can be surmised to be so because the reduced amount of wind and turbulent mixing in the quiet/calm zone could have produced an effect on crop temperatures and then the yield [16, 13]. This is also because reduction in wind speed reduces the amount of evaporation from leaves' surfaces, the manure applied could have served as source of moisture for the okra to compensate for possible reduced evaporation by scorching sun. The implication of the findings is that lowering of temperature-humidity index values at the surfaces of the okra leaves which can be achieved through orientation of crop to the prevailing wind and keeping the crop at predetermined height of growth will help the growth and yield of okra. This is because the 1 m wind's height level allows low turbulent air mixing on the crop's surface which was good for crops. Wind movements especially when it has turbulent mixing in the quiet zone will produce effect on crops' ambient temperatures and THI and then on the leafy yield of okra. Also, it could have helped in the improvement in the performances of the crop as there could have been reduced evapo-transpiration from the okra and thus resulted comfortability that will lead to their good growth. Thus the consequences that vegetative yield will increase and provide more income for the farmers and enhancing positively our food security.

CONCLUSIONS

Application of rice bran and poultry manure in ratio 1:2 in the soil enhanced all the yield components of okra such as plant height, number of plant leaves, number of branches per plant and stem girth. Different organic treatments for okra affect its performances via growth parameters when the wind's speed was at 1 m height. Okra will do well vegetatively when wind speed is less than 50 km/h in any good soil of good moisture to cater for reduced evaporative cooling on its leaves.

ACKNOWLEDGEMENTS

We thank the Osun State University Teaching and Research Farm for their support and valuable help in the use of their facilities.

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