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RESPONSE OF WILLIAMS BANANA PLANTS TO BIOFERTILIZATION IN RELATION TO GROWTH, PRODUCTIVITY AND FRUIT QUALITY

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ABSTRACT

The present investigation was carried out during 2000/2001 and 2001/2002 seasons on the second and third ratoons of Williams bananas grown in a private farm located at Mansorea, Giza Governorate Egypt. An experiment was conducted to investigate the response of Williams banana plants to biofertilizer in the presence of reduced doses of chemical fertilizers i.e. (25, 50 and 75% NPK) on growth, yield components and fruit quality. The standard treatment (100% NPK) revealed an increase in the length and diameter of pseudostem, number of green leaves per plant and leaf area. The treatments received 25 or 50% NPK plus biofertilizers produced slight increases in the studied vegetative growth parameters. However, the treatment of fertilization with 75% NPK combined with biofertilizer was the most superior one. Application of 75% NPK plus biofertilizer caused significant increases in macronutrients contents in leaves compared with either 25 or 50% NPK with biofertilization or the recommend dose of NPK alone. Biofertilized Williams banana plants were increased the length and weight of bunch, number of fingers/bunch and number of hands/bunch. The yield and yield components increased by increasing the NPK levels from 25% up to 100%. The yield significantly increased as a result of receiving 75% NPK plus biofertilizer compared with other treatments. The fruit quality properties were improved by the application of biofertilizer. The values of fruit physical properties were increased by the application of the biofertilizer plus 25, 50 or 75% NPK. The treatment of biofertilization plus 75 % NPK gave the highest values of fruit quality (the contents of pulp from total soluble solids, total sugars, acidity and starch) followed by 50% NPK plus biofertilizer and 100% NPK alone.

Key word: Banana plants, Williams banana cv., Chemical fertilizer, Biofertilizer, Yield, Fruit quality.

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INTRODUCTION

Banana *(Musa spp.)* is considered one of the most important and popular fruit crops in Egypt for its high nutritive value with a highly organized and developed industry. Banana plays an important role in the economy of tropical and subtropical countries as a cash crop for exportation and as a complementary food in local sets. Its fruits may be consumed either fresh or processed into juice, banana puree, flour, dried catsup, ships, alcohol, vinegar, beers, spirits and as a source of carbohydrate **(Palmer, 1979).** In Egypt, the total cultivated area in 2001 was 52487 feddans with a total production of about 760505 tons according to the latest statistics of Ministry of Agriculture. It is well known that banana needs large amounts of fertitizers especially nitrogen and potassium. Moreover, it drows nutrients from a very limited soil depth because of its shallow root system **(Saleh, 1996).** So, the major problems facing banana growers are the high costs of excessive manufactured fertilizers needed for banana plants. Besides, these chemical fertilizers are considered as air, soil and water polluting agents during their production and utilization.

The pollution of the soil and water resulted from leached chemical fertilizers into the soil, which transferred through the plants to the human and cause serious diseases. Consequently, it has drown the attention of researchers and banana growers to use the biofertilizer, which are safe for human, animal, and environment. Thus, it is preferred to avoid pollution and reduce the costs of fertilizers. Furthermore, the use of biofertilizer was suggested to be one possibility to restore the natural conditions.

Biofertilizers are biological preparations containing sufficient densities of potent strains of microorganisms having a definite beneficial role in furnishing a proper rhizosphere for plant growth. However, it is worthy to mention that biofertilizers, at time being, do not completely replace agrochemicals, but significantly reduce their rates of application **(Saber, 2001)**

The purpose of this study was to investigate the response of Williams banana plants to biofertilizers with reducing the doses of chemical fertilizers and the effect on plant growth, productivity and fruit quality of Williams banana cv.

MATERIAL AND METHODS

This study was conducted during two successive seasons of 2000/2001 and 2001/2002, on the second and third ratoons of Williams banana cv. grown in a private farm located at Mansorea, Giza Governorate Egypt.

All plants were spaced at 3×3 m. and irrigated with basin irrigation system and all plants received the convential horticultural practices except the fertilization. Twenty stools of Williams banana plants were chosen and every stool contain two plants. The experiment included five treatments, every one represented with four replicates, each replicate contain one stool of Williams banana plants which contained two plants for yielding in the current season and two plants for yielding in the following season.

A- Application of chemical fertilizers

1- **Nitrogen** was applied as ammonium sulphate (20.5% N) at equal seven monthly applications from April till

October at rates of 300, 225, 150 and 75 gm/plant/month to represent 100, 75, 50 and 25% from the recommended dose of the chemical fertilizer treatments, respectively.

2- **Super phosphate** (16% P_2O_5) was added in January at rates of 250, 188, 125 and 63 gm/plant as 100, 75, 50 and 25% from the recommended dose of the chemical fertilizer treatments, respectively.

3- **Potassium** was added as potassium sulphate (48% K_2O) at three equal doses in April, June and July at 200, 150, 100 and 50 gm/plant as 100, 75, 50 and 25% from the recommended dose of chemical fertilizer treatments, respectively.

B- Preparation and application of biofertilizer

Multibiofertilizer (phosphate dissolving bacteria (PDB), *Azotobacter spp., Azospirillum spp., and Psendomonas spp.* was prepared by mixing highly efficient local strains in equal amounts of each strain broth after separately grown in specific nutrient broth (**Difco, 1969**) for 48 hours at 30°C in a rotary shaking incubator. Liquid broth cultures initially containing 9×10^8, 2×10^8, 5×10^8 and 3×10^8 viable cell/ml of PDB, *Azotobacter spp, Azospirillum spp. and Pseudomonas spp.*, respectively and applied at the rate of 1.75 liter per stool well distributed around the plants at equal seven monthly applications during ammonium sulphate addition.

Fertilization treatments

1- The recommended NPK amount (100%NPK, control).
2- Biofertilizer + 25% NPK.
3- Biofertilizer + 50% NPK.
4- Biofertilizer + 75% NPK.
5- Biofertilizer alone.

Irrigation was conducted after the addition of NPK and or biofertilizer in both seasons.

The following parameters were considered in the present work:

I- Measurements of vegetative growth parameters

After the emergence of the inflorescence (at the beginning of September in both seasons). The following characters were determined:

a- Pseudostem length in cm. from the soil surface up to the petiole of the last emerged leaf.
b- Circumference of the pseudostem at the base (10 cm over the soil surface), middle and at the top of pseudostem, then the average was calculated and recorded.
c- Number of green leaves per plant.
d- Leaf area, (in square meter) using the third full sized leaves according to (**Murry 1960**) and calculated as follows: length × width × 0.8.

II- Leaf mineral analysis contents

Leaf samples were taken from the third upper leaf from the top of the plant after brunch shooting in September of each season. A sample of 10×10 cm from the middle part of the leaf blade was used

as recommended by **Hewitt (1955)** and adopted by **Abou-Aziz *et al* (1987)** for N, P and K determination according to **A.O.A.C. (1984).**

Table 1. Physical and chemical analysis of the experimented soil

Character	Value
Particle size distribution	
Clay %	31.3
Silt %	42.5
Sand %	26.2
Texture	Silt Clay Loam
EC m. mohs /cm (1:2.5)	0.39
PH (1:2.5 suspension)	8.15
Organic matter %	1.75
Total carbonate %	1.63
Available macro-nutrients	
N %	0.11
P ppm.	13.0
K ppm	371.0
Available micro-nutrients	
Zn ppm	1.00
Cu ppm	1.2
Fe ppm	5.3

III- Yield and fruit quality

Bunchs were harvested at the full maturity stage (in the last weak of December in both seasons). The bunch weight, bunch length, hand weight, number of hands per bunch and number of fingers per hand were recorded.

Three hands were taken from the base, middle and distal top end of the bunch as a composite sample for each replicate and artificially ripened by wrapping with newspaper in closed glass-faced boxes. After ripening, fruit physical and chemical characteristics were determined as follows:

a- Finger weight, in (gm) length and diameter in (cm).

b- The weight of pulp and peel of the finger in (gm) then the percentage of pulp was calculated with reference to the whole weight of ripened finger.

c- Total soluble solids (T.S.S., total sugar, total titratable acidity and starch contents were determined in the pulp according to **A.O.A.C. (1984)** as well as T.S.S. / acid ratio.

Statistical Analysis

All the obtained data were tabulated and statistically analyzed according to **Sendecor and Cochram (1972)** using L.S.D. test at 0.05 level .

RESULTS AND DISCUSSIONS

1- Effect of biofertilization on vegetative growth parameters

Data in Table (2) show the effect of chemical fertilizer and biofertilizer treatments on the pseudostem length, pseudostem circumference, No. of green leaves per plant and leaf area of Williams banana plants during 2000/2001 and 2001/2002 seasons.

Concerning the effect of chemical fertilizer and biofertilizer treatments on the pseudostem length, it is apparent that increasing the rate of NPK from 25% to 75% increased pseudostem length,

Table 2. Effect of biofertilizer under different levels of chemical fertilization on vegetative growth parameters of Williams banana plants during 2000/2001–2001/ 2002 seasons.

Treatments \ Parameter	Pseudostem length (cm)	Pseudostem circumference (cm)	No. of green leaves per plant	Leaf area $(m)^2$
2000 / 2001 season				
100% NPK (control)	304.13	78.22	17.75	10.84
25% NPK + biofertilizer	231.50	71.56	13.75	1.89
50% NPK + biofertilizer	265.36	74.88	14.00	1.53
75% NPK + biofertilizer	327.13	86.42	-16.00	1.96
Biofertilizer alone	210.33	67.40	12.35	1.43
L.S.D. at 0.05	5.52	4.66	0.95	0.05
2001/2002 season				
100% NPK (control)	301.30	80.00	15.50	1.87
25% NPK + biofertilizer	233.00	72.20	13.00	1.40
50% NPK + biofertilizer	270.25	76.00	14.00	1.44
75% NPK + biofertilizer	329.75	88.19	16.35	1.98
Biofertilizer alone	215.00	68.00	12.50	1.33
L.S.D. at 0.05	6.25	4.75	0.98	0.08

pseudostem circumference, No. of green leaves/plant and leaf area. However, the application of 75% NPK in the presence of biofertilizer gave the highest value of vegetative growth parameters than the other treatments which received 50 or 25% NPK plus the biofertilizer or 100% NPK alone in both experimental seasons. These effects on of vegetative growth parameters of Williams banana plants as a result of addition of the biofertilizer may be due to its effect directly and indirectly on the availability of nutrients in the soil as well as improving and increasing their uptake by roots and its use in the metabolism of the plants.

Also, these results could be attributed to numerous soil microorganisms such as, *Azospirillum and Pseudomonas* which produce growth promoting principles in rhizosphere e.g., gibberellin, cytokinin-like substances and auxins **Dobernier & Pedrosa (1987) and Saber & Gomaa (1993).**

2- Effect of biofertilization on leaf macronutrients content

Results in Table (3) revealed that increasing the rate of NPK plus biofertilizer generally associated with a gradual and significant increase in the percentage of nitrogen, phosphorus and potassium in the leaves in both the experimental seasons.

Table 3. Effect of biofertilizer under different levels of chemical fertilization on nitrogen, phosphorus and potassium contents of Williams banana leaf during 2000/2001-2001/2002 seasons.

Element / Treatments	2000/2001			2001/2002		
	N %	P %	K %	N %	P %	K %
100% NPK (control)	2.93	0.29	3.00	3.05	0.33	3.10
25% NPK + biofertilizer	2.10	0.18	2.69	2.18	0.20	2.03
50% NPK + biofertilizer	2.38	0.21	2.97	2.39	0.23	2.99
75% NPK + biofertilizer	3.48	0.34	3.30	3.95	0.39	3.25
Biofertilizer alone	1.80	0.16	2.40	1.85	0.18	2.37
The optimum level of nutrient *	2.80 -3.00	0.17 -0.24	3.15 -3.32	2.80-3.00	0.17-0.24	3.15-3.32
L.S.D. at 0.05	0.42	0.03	0.08	0.36	0.05	0.09

* The optimum level of nutrient according to **Hewitt (1995) and Nijjar (1985).**

Furthermore, the treatment of 75% NPK+ biofertilizer was more effective on leaf macronutrients content than the other treatments which fertilized with 25% or 50% NPK from the recommended dose combined with the biofertilizer in the two studied seasons. These effects could be due to that a set of soil microorganisms, processing the ability and mobilizing the unavailable forms of nutrient elements to be available for absorption by roots.

These results are in the line with those of **Fernandez-Falcen *et al* (1998); Tiwary *et al* (1999); Soliman, 2001; Magda Mostafa (2002) and Radwan & Awad (2002).**

3- Effect of biofertilizer on yield and yield components

Results in Table (4) show that bunch length, bunch weight, No. of hand/bunch and No. of fingers/hand significantly increased by increasing NPK rate applied to Williams banana plants from 25% up to 100% per stool in both seasons. Moreover, the addition of the biofertilizer increased the yield and yield components in the two studied seasons.

The results in the same Table indicated that addition of 100% NPK significantly increased the yield and yield components in comparison with the fertilization with 50% or 25% of the recommended dose plus the biofertilizer in both seasons of study. Moreover, the application of 75% NPK enriched with the biofertilizer increased significantly the yield and yield components than other studied treatments.

The effect of chemical fertilizers and the used biofertilizer on bunch length, bunch weight, No. of hand/bunch and No. of fingers / hand could be attributed to its

Table 4. Effect of biofertilizer under different levels of chemical fertilization on yield and yield components of Williams banana plants during 2000 / 2001 – 2001/2002 seasons.

Parameter / Treatments	Bunch length (cm)	Bunch weight (kg)	No. of hands/bunch	No. of fingers/hand
2000 / 2001 season				
100% NPK (control)	99.13	25.47	10.38	19.16
25% NPK + biofertilizer	90.00	21.61	9.13	16.13
50% NPK + biofertilizer	98.18	25.37	9.50	19.13
75% NPK + biofertilizer	115.25	39.35	11.50	25.55
Biofertilizer alone	84.00	18.01	9.00	15.78
L.S.D. at 0.05	5.76	2.85	0.87	2.45
2001 / 2002 season				
100% NPK (control)	101.50	26.78	10.56	19.58
25% NPK + biofertilizer	89.52	23.61	9.25	16.63
50% NPK + biofertilizer	100.50	26.27	4.75	19.33
75% NPK + biofertilizer	118.70	41.31	11.63	26.13
Biofertilizer alone	85.00	19.09	9.10	16.00
L.S.D. at 0.05	6.62	2.95	0.73	2.82

role in increasing amino acids content which considered as a constituent of proteins and other compounds that share in the development of new tissues **Tiwary *et al* (1999) and Smith (1998)**. Also, biofertilizer increased the contents of growth regulators such as IAA and cytokinins which stimulated plant growth **Li *et al* (1998)**. Also, the effect of NPK and the biofertilizer increased cell division and enlargement and consequently increased vegetative growth which reflected on increasing the yield and yield components as finally result from the physiological processes **Abd El-Naby, (2000); Geetha & Nair (2000) and Magda-Mostafa (2002).**

4- Effect of biofertilization on Fruit quality

The results presented in Table (5) indicate that the addition of biofertilizer achieved significant increase in hand weight, finger length, finger diameter and finger weight as compared with the treatment of 100% NPK alone in the two studied seasons.

Furthermore, the treatment of 75% NPK plus biofertilizer gave higher values

Table 5. Effect of biofertilizer under different levels of chemical fertilization on Fruit quality of Williams bananas during 2000/2001 – 2001/ 2002 seasons..

Fruit quality / Treatments	Hand Weight (kg)	Finger Length (cm)	Finger Diameter (cm)	Finger Weight (gm)	Peel Weight (gm)	Pulp Weight (gm)	% of pulp/ finger
2000 / 2001 season							
100% NPK (control)	2.27	20.53	3.80	118.25	31.83	86.42	73.08
25% NPK + biofertilizer	2.07	18.11	3.25	112.70	34.80	77.90	69.12
50% NPK + biofertilizer	2.25	20.29	3.64	119.08	34.78	84.30	70.79
75% NPK + biofertilizer	3.27	22.17	3.99	127.64	32.19	95.45	74.78
Biofertilizer alone	1.85	17.47	3.00	108.80	34.00	74.80	68.75
L.S.D. at 0.05	0.26	1.27	0.09	5.45	3.63	3.43	2.27
2001 / 2002 season							
100% NPK (control)	2.37	21.02	3.86	119.88	32.57	87.31	72.83
25% NPK + biofertilizer	2.10	18.60	3.50	113.45	34.65	78.77	69.43
50% NPK + biofertilizer	2.31	20.47	3.71	114.30	34.20	80.10	70.08
75% NPK + biofertilizer	3.38	22.25	4.00	129.31	32.91	96.40	74.55
Biofertilizer alone	1.90	17.56	3.10	110.92	34.00	76.92	69.35
L.S.D. at 0.05	0.21	1.33	0.06	5.72	3.55	3.62	2.62

of fruit quality characters than the treatment of 50% or 25% NPK + biofertilizer in the first and second season. NPK and biofertilizer application increased the availability of elements as a constituent of the nucleic acid DNA and RNA **Smith (1998); Chezhiyan *et al* (1999); El-Kobbia (1999) and Abd El-Naby (2000)**. In addition to the role of biofertilizer in increasing the metabolism processes which reflects at the end as carbohydrates and another compounds **Geetha and Nair (2000) and Magda-Mostafa (2002)**.

On the other hand, the obtained data revealed that the peel weight significantly decreased by increasing the rates of NPK, the application of 100% NPK gave lower values of peel weight compared to fertilization with 75, 50 or 25%NPK in the presence of biofertilizer in both experimental seasons. The same table declared that the pulp weight and percentage of pulp in the finger increased by application of NPK and biofertilizer. Moreover, the treatment of 75% NPK and the biofertilizer showed the highest pulp weight and percentage of pulp in the finger.

5- Effect of biofertilization on fruit chemical properties of the pulp

Data present in Table (6) declared the total soluble solids%, total titratable acidity %, T.S.S/acidity ratio, total sugars and starch contents in the pulp of fingers of Williams banana plants. It is evident that T.S.S, T.S.S/acidity ratio and total sugars in the pulp increased by increasing the rate of NPK from 25%up to 75% in both seasons. Furthermore, the treatment of 100% NPK alone increased T.S.S, T.S.S/acidity ratio and total sugars compared with biofertilizer plus 25% or 50% from the recommended dose of NPK in both experimental seasons. On the other hand, the addition of 75% NPK to biofertilized plants gave the highest values of T.S.S, T.S.S/acidity ratio and total sugars in the pulp of fingers in the first and second season, respectively.

Table 6. Effect of biofertilizer under different levels of chemical fertilization on chemical properties of Williams banana fruits during 2000/2001 – 2001/ 2002 seasons.

Chemical properties / Treatments	T.S.S %	Total titratable acidity gm/100gm pulp	T.S.S/ acidity ratio %	Total sugars %	Starch %
2000 / 2001 season					
100% NPK (control)	21.90	0.360	60.83	18.72	2.20
25% NPK + biofertilizer	19.83	0.380	52.18	16.54	2.27
50% NPK + biofertilizer	20.20	0.390	51.79	17.05	2.26
75% NPK + biofertilizer	22.68	0.320	70.88	19.61	1.95
Biofertilizer alone	19.00	0.400	47.50	16.10	2.40
L.S.D. at 0.05	1.22	0.017	4.80	1.60	0.08
2001 / 2002 season					
100% NPK (control)	22.20	0.353	62.89	18.89	2.17
25% NPK + biofertilizer	20.00	0.395	50.63	16.21	2.35
50% NPK + biofertilizer	20.53	0.370	55.49	17.11	2.23
75% NPK + biofertilizer	23.20	0.310	74.84	20.19	1.90
Biofertilizer alone	19.25	0.390	49.36	16.00	2.42
L.S.D. at 0.05	1.35	0.012	4.92	1.55	0.05

Moreover, data in the same Table (6) indicated that the increment in the rate of NPK from 25% to 75% plus biofertilizer decreased the titratable acidity and starch % in the pulp of the fingers in the two experimental seasons.

The treatment of 100% NPK alone resulted in the lowest acidity and starch % in comparison with the rates of 25%, 50% or 75% NPK enriched with biofertilizer. The treatment of 75% NPK plus biofertilizer showed the lowest percentage of acidity and starch in the pulp of finger in the two studied seasons.

The effect of the used biofertilizer and NPK on increasing the T.S.S, T.S.S/ acidity ratio and total sugars and decreasing the percentage of acidity and starch in the pulp of fingers could be due to their beneficial effect on the total leaf area of the plant which reflected in more carbohydrates production through photosynthesis process. From the physiological view, the obtained results could be explained in the light of the role of the biofertilizer as a constituent of prymidins which are in turn constituents of chlorophyll and cytocromes **Tiwary *et al* (1998); Mansour (1998); Tachibana & Yahata (1998); El-Kobbia (1999); Joo *et al* (1999); Abd El-Naby (2000) and Magda-Mostafa (2002)**. In addition to the role of the biofertilizer in increasing the uptake of nutrients which advanced fruit ripening in terms of a decrease in pulp acidity and starch and an increase in T.S.S and total sugars.

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استجابة نباتات الموز الوليامز للتسميد الحيوي وعلاقته بالنمو والمحصول وجوده الثمار

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١- قسم الفاكهة - المركز القومي للبحوث - الدقي - مصر

٢- قسم الميكروبيولوجيا الزراعية - المركز القومي للبحوث - الدقي - مصر

أجريت هذه الدراسة خلال موسمي ٢٠٠٠/٢٠٠١و ٢٠٠١/٢٠٠٢ في مزرعة خاصة بالمنصورية محافظة الجيزة على الخلفة الثانية والثالثة لنباتات الموز الوليامز بغرض دراسة تأثير إضافة التسميد الحيوي في وجود دفعات منخفضة من الأسمدة الكيماوية (٢٥ ، ٥٠ ، ٧٥% ن ، فو، بو من المعدل الموصى به في تسميد الموز) على الصفات الخضرية والمحتوى المعدني للأوراق وعلى المحصول ومكوناته وجودة الثمار.

أدت معاملة المقارنة (١٠٠% ن، فو، بو منفردا) إلي زيادة في طول وسمك الساق الكاذب كذلك زيادة في عدد الأوراق الخضراء ومساحة الورقة ، كما أدى استخدام (٥٠ أو ٢٥%) تسميد كيماوي بالإضافة إلى السماد الحيوي إلي زيادة في كل الصفات الخضرية المدروسة ومع ذلك تفوقت المعاملة (٧٥%) سماد كيماوي في وجود السماد الحيوي على باقي المعاملات الأخرى تحت الدراسة.

زاد المحتوى المعدني للأوراق من كل من النيتروجين والفوسفور والبوتاسيوم زيادة معنوية عند استخدام ٧٥% تسميد كيماوي مع السماد الحيوي وذلك بالمقارنة باستخدام ٢٥ أو ٥٠ % سماد كيماوي في وجود السماد الحيوي أو بالتسميد الكيماوي منفردا (١٠٠% ن ، فو ، بو).

أدى التسميد الحيوي للنباتات إلى زيادة طول السوباطة ووزنها وعدد الأصابع بها وعدد الكفوف ، ونتج عن استخدام السماد الحيوي في وجود التسميد الكيماوي زيادة في المحصول ومكوناته زيادة معنوية.

زاد محصول الموز الوليامز زيادة مؤكدة إحصائيًا في النباتات المعاملة بإضافة ٧٥% سماد كيماوي + سماد حيوي بالمقارنة بباقي المعاملات.

تحسنت صفات الجودة الطبيعية للثمار باستخدام السماد الكيماوي ١٠٠% (ن، فو، بو)، وزادت القيم المتحصل عليها للصفات الطبيعية المدروسة عند استخدام ٥٠ ،

٢٥% سماد كيماوي مع السماد الحيوي.

وأمكن الحصول على ثمار ذات صفات جودة عالية نتيجة المعاملة ٧٥% سماد كيماوي + تسميد حيوي حيث أعطت هذه المعاملة صفات جودة عالية من حيث محتوى اللب من المواد الصلبة الذائبة والسكريات الكلية والحموضة والنشا.

عموماً فإن إضافة السماد الحيوي + ٧٥% من المعدلات الموصى بها من السماد الكيماوي إدت إلي زيادة المحصول وحسنت صفات جوده الثمار.

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