

Response of Okra to Incorporating Humic acid-derived Active Molecules into NPK Fertilizer and Lime on Coastal Plain Sand in Calabar, Nigeria

ABSTRACT

This study evaluated the response of okra to NPK fertilizer with humic acid and lime at the University of Calabar, Teaching and Research Farm between October, 2015 and January, 2016 cropping season. The experimental was laid out in a randomized complete block design (RCBD) with four replications. The experiment consisted of NPK with humic acid and liming materials as treatments. The test crop was okra. The result of initial analysis of the chemical properties of the soil before the experiment showed that the soil was acidic and was low in exchangeable bases, organic matter (1.13%), total nitrogen (0.14%) and ECEC but high in available phosphorus (26.63mg/kg) and base saturation. After treatment of application the result showed that 6.2g of lime and 4.6g of NPK with humic acid increase the soil pH from 5.6 units in the control to 5.8 in NPK with Humic Acid, 6.0 in NPK with Humic Acid and lime and 6.4 in lime. Organic carbon content, total nitrogen and available phosphorus also increases in like manner. The results of the growth parameters showed that okra height, number of leaves, and pod yield were significantly ($p \leq 0.05$) different from the control. Based on the result of this study further research is recommended in other locations to fully ascertain the effects of this treatment using different combination.

Keywords: Okra, Coastal plain sand, Humic acid, Lime, fertilizer

1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L) Moench), also known as ladies' fingers in many English-speaking countries is a flowering plant that belongs to the family mallow, and it is popularly grown for its immature fruits and young leaves throughout the tropical and sub-tropical parts of the world. In Nigeria and other African countries, okra is often grown in gardens as mixed crop alongside other arable crops [1]. Okra occupies about 1.5 million hectares of the arable land in Nigeria alone [2] while the world production of okra as fresh fruit is estimated at 1.7 million t/year [3].

Although okra has great potential both as domestic and commercial crop in Nigeria, but its yield on peasant farmer's fields is often very low, yielding about 2.10 t ha⁻¹ in Nigeria, which is far less compared to other countries like India (10.12 t ha⁻¹) and world average (7.65 t ha⁻¹) [4]. However, inadequate knowledge of the management of the soils, improved

41 varieties and some of the necessary cultural practices such as optimum plant density, and
42 nutrient requirements might have contributed to the low okra yield obtained by these farmers
43 [5].

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45 Soils of the rain forest zone of Nigeria are acidic in nature, classified as Ultisols and Oxisols
46 which are inherently low in pH, organic matter, nitrogen, potassium and other nutrients [6,7].
47 These soils are prevalent in areas experiencing high annual rainfall (above 1500mm) and
48 usually have problems associated with aluminum toxicity, low nutrient status, nutrient
49 imbalance and multiple nutrient deficiencies [8] and therefore require fertilization and liming
50 for good crop growth and yield. Nitrogen is the main limiting nutrient for most crops on these
51 soils because of heavy leaching as a result of high rainfall exacerbated by the sandy nature of
52 the soils [9].

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54 Liming is a soil amendment management strategy of applying substances to manage or raise
55 the pH of the soil to a favorable level. The overall effects of lime on soils include increased
56 pH, Ca, Mg and P availability, neutralization of toxic concentrations of Al and Mn increase in
57 pH dependent CEC and improved nutrient uptake by plants [10,11]. According to
58 Oluwatoyinbo *et al.* [12], lime reduced the amount of fertilizer P required for optimum
59 growth and fruit yield of okra and obtained the highest yield at 0.5t/ha lime rate. There is
60 need for agricultural practices which are cheap and affordable for the local farmers, although
61 accurate rates of these local liming materials are yet to be established for optimum yield [13].
62 Okra is often sensitive to slightly acidic soil in the tropics and hence is used as a test crop in
63 this experiment.

64 It is worthy of note that nutrient management is the main factor that is accountable for
65 sustainable soil fertility. Over the years the use of inorganic fertilizer on crops increased yield
66 as well as economic return on investment. Humic acid is the active constituent of organic
67 humus, which can play a very important role in soil conditioning and plant growth [14].
68 However, recent researches have explored the study area under investigations in the context
69 of mineral and organic fertilizers effect on crop growth and nutrient uptake [15, 16, 17,18],
70 but no study was found specific to incorporating humic acid-derived active molecules into
71 NPK fertilizer to ascertain its effect in crops in Calabar environment, which is an important
72 food producing area in Cross River State. However, this study seeks to examine the response
73 of okra to incorporating humic acid-derived active molecules into NPK fertilizer and lime
74 on coastal plain sand in Calabar, Nigeria.

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77 **2. MATERIALS AND METHODS**

78 **2.1 Description of the Study Area**

79 The study was conducted between October, 2015 and January, 2016 in poly pots laid out in
80 the open field at Crop Science Teaching and Research farm of the University of Calabar.
81 University of Calabar lies between latitude $05^{\circ}32'$ North and longitude $07^{\circ}15'$ and $9^{\circ}28'$ East
82 [18]. The climate of the study area was characterized by high relative humidity and rainfall.
83 Rainfall is usually heavy occurring between the months of March to October with short dry
84 spell in August. The mean total annual rainfall exceed 3000 mm per annum and the relative
85 humidity of 85% with the mean annual minimum and maximum temperature of 22.93°C and
86 26.51°C [19]. The rainfall spreads between April and October and characterized by two peak
87 periods and a short break in the month of August known as 'August break'.

88

89 **2.2 Soil sampling and Sample preparation**

90 The experimental site has been previously cultivated for yam, cassava, water leaf, fluted
91 pumpkin, okra, maize etc. The experimental site was cleared, winnowed and the surface
92 debris was removed before randomly collecting the soil samples. The soil samples were
93 collected at the depth of 0-30cm as a composite of four (4) auger points from the
94 experimental site. The samples were thoroughly mixed together and 1.5kg of the soil sample
95 weighed into each pot of length 17cm and diameter 16.5cm.

96

97 **2.3 Experimental Design, Treatment, Planting and Planting Materials**

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99 The experimental was laid out in a randomized complete block design (RCBD) with four
100 replications. The experiment consisted of NPK+ humic acid and liming materials as
101 treatment. The test crop okra and liming materials were gotten from Calabar local market,
102 while NPK with humic acid was obtained from commercial fertilizer plant in Jinan City,
103 China. The composition of lime use is Calcium Carbonate (CaCO_3) and composition of NPK
104 with humic acid; N_2 (10%), P_2O_5 (5%), K_2O (25%), micro-nutrients, that is, Baron, Zinc,
105 Manganese, Iron, Molybdenum were all 0.1% and humic acid (3%).

106 **2.4 Data Collection**

107 Data was collected on growth parameters include plant height, number of leaves, leaf length
108 and leaf width. The number of leaves was determined by counting each plant once in two
109 weeks. The tools that were used for growth parameter data was meter rule. Biomass data
110 include stem girth and yield was considered at the end of the experiment.

111

112 **2.5 Laboratory Analysis**

113 In the laboratory, the soil sample collected was air dried, sieved using 2mm sieve, stored and
114 analyzed for physical and chemical properties using standard procedures. Particle size
115 distribution was determined by the hydrometer method using sodium hexametaphosphate
116 (calgon) as the dispersant [20]. The percentages of sand, silt and clay were determined. The
117 pH (in water) was determined in soil water ratio of 1:2.5 using a glass electrode pH meter
118 standardized with buffer solutions 4.0 and 6.85 [20]. Organic carbon was determined by the
119 Walkley and Black wet oxidation method described by Udo *et al.* [20]. Total nitrogen was
120 determined by Macro-Kjeldahl Distillation Method [21] using Sodium Sulphate (NaSO_4) and
121 Copper Sulphate (CuSO_4) as a catalyst. Available phosphorus was extracted using the Bray-1
122 method [22] and determined calorimetrically with a spectrophotometer. Exchangeable bases
123 (Ca, Mg, K and Na) were extracted in 1 N NH_4OAc at pH 7. Potassium and sodium were
124 determined with a flame photometer while calcium and magnesium were determined by the
125 EDTA titration method [23]. Exchangeable acidity was by titration method using 1 N KCl
126 extract [24]. Cation Exchange Capacity (CEC) was by summation of exchangeable bases
127 while Effective Cation Exchange Capacity (ECEC) was a summation of exchangeable bases
128 (Ca, Mg, K and Na) and exchangeable acidity. Percent base saturation was obtained by
129 dividing the total exchangeable bases (Ca, Mg, K and Na) by the effective cation exchange
130 capacity.

131 **2.6 Data Analyses**

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133 The data was statistically analyzed using Analysis of Variance (ANOVA). Means were
134 compared using F-LSD test at 0.05 level of probability [25].

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136 **3. RESULTS AND DISCUSSION**

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138 **3.1 Physical Properties**

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140 **3.1.1 Particle size Analysis**

141 The soil was high in sand (73.0%, 74.0% and 76.0%) for NPKHA, control and NPKHA +
142 Lime and Lime, silt (14%, 15%, 16%, and 18%) for Lime, NPKHA + Lime, control and
143 NPKHA and the clay (9%, 10%, and 11%) for NPKHA, control and Lime, and NPKHA +
144 Lime. The soil still maintain sandy loam as its textural classes and such soil lack the
145 absorption capacity for basic plant nutrients and water [26].

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147 **3.2 Chemical Properties**

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149 **3.2.1 Soil pH**

150 The pH increases with treatment, for instance control (5.6), NPKHA (5.8), NPKHA + Lime
151 (6.0), and lime (6.4). The acidic conditions of the soils might be due to the high rainfall
152 which could leach out basic cations from the soil solum in the area.

153

154 **3.2.2 Organic Carbon**

155 The organic carbon content increase with treatments, for instance control (1.12%), NPKHA +
156 Lime (1.54%), Lime (1.56%) and NPKHA (1.70%) which is below the critical level of 2%
157 for soils of the humid tropical region [27,28]. **This low value obtained for the result might be**
158 **due to acidic nature of the humic acid fertilizer and non-availability of organic materials in**
159 **the treatments.** However, the value can be increase by including organic sources as part of the
160 treatments

161 **3.2.3 Total nitrogen**

162 The value of total nitrogen reduces from control (0.07%), NPKHA + Lime and Lime (0.05%)
163 and NPKHA (0.03%) which was lower than the critical level of 1.5% given by Aduayi *et al.*
164 [27]. Meanwhile nitrogen is one of the main nutrients needed by these crops and because of
165 heavy leaching as a result of high rainfall, exacerbated by the sandy nature of the soils. It has
166 become one of the most limiting nutrients in the soil.

167

168 **3.2.4 Available phosphorus**

169 The value of available phosphorus increases with the treatments Lime (18.00 mg/kg), control
170 (26.61 mg/kg), NPKHA (34.75 mg/kg) and NPKHA + Lime (40.13 mg/kg) as compared to
171 the critical level of 8 mg/kg given by Aduayi *et al.* [27]. There was also a significant increase

172 in available phosphorus, except on the sole application of lime which yielded the least
173 available phosphorus.

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175 **3.2.5 Exchangeable Calcium, Magnesium, Potassium and Sodium**

176 The value of calcium present in the soil increases with treatment Lime (4.5 cmol/kg),
177 NPKHA + Lime (3.9 cmol/kg), NPKHA (3.6 cmol/kg) and control (2.4 cmol/kg). The value
178 of magnesium present increase with treatment Lime (2.7 cmol/kg), NPKHA + Lime (2.01
179 cmol/kg), NPKHA (1.6 cmol/kg) and control (0.6 cmol/kg). There was significant increase in
180 the exchangeable Ca^{++} in the treatment with Lime as well as the combination of Lime and
181 NPK with humic acid yielding the highest exchangeable Ca^{++} . The value of potassium in the
182 soil slightly increases with treatment Lime (1.08 cmol/kg), NPKHA + Lime (0.11 cmol/kg),
183 control (0.09 cmol/kg), NPKHA (0.08 cmol/kg). There was no significant increase in
184 magnesium and sodium. The values of sodium present in the soil increases with treatment
185 NPKHA and NPKHA + Lime (1.2 cmol/kg), Lime (0.91 cmol/kg) and Control (0.07
186 cmol/kg).

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188 **3.2.6 Exchangeable acidity**

189 The values of Al^{+++} reduce in treatment with lime was 0.01 (cmol/kg) and NPKHA + Lime
190 0.09 (cmol/kg). The exchangeable acidity was low, this influencing the biochemical behavior
191 of the soils. The values of H^+ increased with treatment Lime 0.40 (cmol/kg), NPKHA + Lime
192 (0.90 cmol/kg) and NPKHA (1.0 cmol/kg) and control (2.3 cmol/kg).

193

194 **3.2.7 Effective Cation Exchange Capacity**

195 The value of ECEC was low in control as established for productive soil. The values of lime
196 and NPKHA + Lime were also. This can be attributed to the low content of exchangeable
197 cation.

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199 **3.2.8 Base Saturation**

200 The base saturation (Ca, Mg, K and Na) increases with treatment indicating that the supply of
201 nutrients in the soil can support growth to an extent. This show that the exchange complex of
202 the soil particles is occupied by reserved acidity. There was a significant increase in the base
203 Saturation (BS) with soils treated with sole applications of Lime giving the highest BS of
204 95.73%. The implication of this lime can reduce acidity and increase the exchangeable
205 cations thereby making the soil fertile.

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Table 1: Soil properties before Experiment

| Physico-chemical properties | Quantity |
|---------------------------------------|-----------------|
| Sand (%) | 74.0 |
| Silt (%) | 16.0 |
| Clay (%) | 10.0 |
| pH (H ₂ O) | 5.6 |
| Org. Carbon (%) | 1.13 |
| Total nitrogen (%) | 0.14 |
| Av. P (mg/kg) | 26.63 |
| Exchangeable cations (cmol/kg) | |
| Ca ²⁺ | 2.4 |
| Mg ²⁺ | 0 |
| K ⁺ | 0.09 |
| Na ⁺ | 0.07 |
| Exchangeable acidity (cmol/kg) | |
| Al ³⁺ | 1.32 |
| H ⁺ | 2.36 |
| ECEC | 6.64 |
| B.S (%) | 44.58 |

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Table 2: Physico-chemical after application of treatment

| properties | Control | NPKHA | NPKHA+Lime | Lime |
|---------------------------------------|----------------|--------------|-------------------|-------------|
| Sand (%) | 74 | 73 | 74 | 76 |
| Silt (%) | 16 | 18 | 15 | 14 |
| Clay (%) | 10 | 9 | 11 | 10 |
| pH | 5.6 | 5.8 | 6.0 | 6.4 |
| Organic Carbon (%) | 1.12 | 1.70 | 1.52 | 1.56 |
| Total Nitrogen (%) | 0.07 | 0.03 | 0.05 | 0.05 |
| Av. P | 26.61 | 34.75 | 40.13 | 18.00 |
| Exchangeable cation (cmol/kg) | | | | |
| Ca ⁺⁺ | 2.4 | 3.6 | 3.9 | 4.5 |
| Mg ⁺⁺ | 0.6 | 1.6 | 2.01 | 2.7 |
| K ⁺ | 0.09 | 0.08 | 0.11 | 1.08 |
| Na ⁺ | 0.07 | 1.2 | 1.2 | 0.91 |
| Exchangeable acidity (cmol/kg) | | | | |

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|-------------------|-------|-------|-------|-------|
| Al ⁺⁺⁺ | 1.32 | 4.4 | 0.09 | 0.01 |
| H ⁺ | 2.34 | 1.0 | 0.90 | 0.40 |
| ECEC | 6.82 | 11.88 | 9.64 | 9.60 |
| B.S (%) | 46.33 | 54.55 | 74.90 | 95.73 |

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217 3.3 Growth Parameter

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219 3.3.1 Plant Height and Number of Leaves

220 In table 3, the response of okra to NPK with humic acid plus lime (NPKHA + Lime) in height
 221 at four sampling periods (3WAP, 5WAP, 7WAP and 9WAP) during the growing seasons
 222 showed that there was no significant increase in height ($p>0.05$) at 3WAP and 9WAP.
 223 However, at 5WAP and 7WAP, there was significant increase in plant height. A close
 224 examination of the data reveals that control and lime pots grew taller than NPKHA + Lime
 225 and NPKHA pots. This is as a result of inability of the plant roots to access the available
 226 nutrients in the soils at different rate of addition of treatments. This result is not in accordance
 227 with the findings of El-Meskser *et al.* [29] who reported that application of humic acid was
 228 associated with a significant increase in plant height of crops.

229 The response of okra to NPKHA and lime on number of leaves were not significant ($p>0.05$)
 230 in 3WAP, 5WAP and 7WAP. At 9WAP, the test crop was significant ($p>0.05$). This is in
 231 agreement with the findings of Oluwatoyinbo *et al* [12], who observed significant increases
 232 in plant height, number of leaves and fruits of okra with the application of all rates of lime up
 233 to the 1000kg/ha rate used.

234

235 3.3.2 Leaf length and Leaf width

236 In table 4, the response of okra to NPK with humic acid plus lime (NPKHA+Lime) in leaf
 237 length and leaf width at four sampling periods (3WAP, 5WAP, 7WAP and 9WAP) during the
 238 growing seasons showed that there was no significant difference ($p\leq 0.05$) in both parameters.

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240 3.3.3 Leaf area index

241 In table 5, the response of okra to NPK with humic acid plus lime (NPKHA +Lime) in leaf
 242 area index at four sampling period (3WAP, 5WAP, 7WAP and 9WAP) during the growing
 243 seasons showed that there was no significant difference at ($p\leq 0.05$) in the leaf area index.

244 This is a pointer to the fact that changes in numbers of leaves are bound to alter the overall

245 performance of the plant as the leaf serves as the photosynthetic organ of the plant [30].
 246 Also the unfertilized plants had lower leaf area due to less number of leaves resulting from
 247 premature leaf fall and early vine senescence [31]. The higher leaf area index associated with
 248 the fertilized plants was probably due to higher number of leaves.

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251 3.3.4 Biomass data and Pod Yield

252 The response of okra to NPK with humic acid plus lime (NPKHA + Lime) in Biomass data
 253 and pod yield is presented in Table 6. The result shows that there was no significant
 254 difference at ($p \leq 0.05$) in stem girth and root. However, there was marginal increase in stem
 255 girth and roots with NPKHA + Lime (2.62 and 0.60). These results is not in harmony with
 256 the findings of Cimrin and Yilmaz [32] who stated that humic substances have been shown to
 257 stimulate shoot and growth and nutrient uptake of vegetable crops.

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259 The result shows that there was significant difference at ($p \leq 0.05$) in pod yield. Crop yield is
 260 significantly increased by integrated use of lime and fertilizer. These results are good
 261 agreement with those obtained by Karakurt *et al.* [33] who found that humic acid enhanced
 262 nutrient uptake, plant growth, yield and quality in a number of plant species. Lime had
 263 significant effect on all the yield attributes name fresh pod weight (Table 6).

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266 **Table 3: Response of NPKHA and Lime on Plant Height and Number of Leaves**

| Treatment | Plant Height | | | | Number of Leaves | | | |
|--------------|--------------|-------|-------|-------|------------------|------|------|------|
| | 3WAP | 5WAP | 7WAP | 9WAP | 3WAP | 5WAP | 7WAP | 9WAP |
| Control | 7.17 | 11.87 | 14.2 | 16.23 | 4.67 | 4.83 | 5.5 | 7.67 |
| NPKHA | 4.35 | 6.05 | 6.88 | 10.52 | 3.16 | 4.33 | 5.33 | 5.5 |
| NPKHA + Lime | 4.28 | 4.9 | 9.02 | 14.93 | 3.16 | 4.00 | 5.17 | 5.83 |
| Lime | 5.28 | 9.12 | 11.97 | 15.27 | 3.83 | 4.5 | 4.67 | 5.67 |
| F-LSD (0.05) | NS | ** | ** | NS | NS | NS | NS | ** |

267 WAP = Week after planting; NPKHA (NPK with Humic Acid) and NPKHA+Lime (NPK with Humic Acid and Lime)
 268 Note: NS means not significant * means Significant at 5 %

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276 **Table 4: Response of NPKHA and Lime on Leaf Length and Leaf Width**

| Treatment | Leaf Length | | | | Leaf Width | | | |
|--------------|-------------|------|------|------|------------|------|------|------|
| | 3WAP | 5WAP | 7WAP | 9WAP | 3WAP | 5WAP | 7WAP | 9WAP |
| Control | 3.26 | 4.67 | 5.1 | 5.82 | 3.6 | 5.43 | 6.38 | 7.52 |
| NPKHA | 2.18 | 3.52 | 2.93 | 4.82 | 2.2 | 3.58 | 4.22 | 6.08 |
| NPKHA + Lime | 2.6 | 4.53 | 6.22 | 6.95 | 2.71 | 5.03 | 7.52 | 8.85 |
| Lime | 3.08 | 3.93 | 4.63 | 5.22 | 3.22 | 4.9 | 4.52 | 6.52 |
| F-LSD (0.05) | NS | NS | NS | NS | NS | NS | NS | NS |

277 WAP = Week after planting; NPKHA (NPK with Humic Acid) and NPKHA+Lime (NPK with Humic Acid and Lime)

278 Note: NS means not significant * means Significant at 5 %

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Table 5: Response of NPKHA and Lime on Leaf Area Index

| Treatment | 3WAP | 5WAP | 7WAP | 9WAP |
|--------------|------|------|------|------|
| Control | 0.04 | 0.03 | 0.04 | 0.05 |
| NPKHA | 0.06 | 0.04 | 0.02 | 0.06 |
| NPKHA + Lime | 0.02 | 0.03 | 0.06 | 0.18 |
| Lime | 0.03 | 0.02 | 0.04 | 0.13 |
| F-LSD (0.05) | NS | NS | NS | NS |

281 WAP = Week after planting; NPKHA (NPK with Humic Acid) and NPKHA+Lime (NPK with Humic Acid
282 and Lime)

283 Note: NS means not significant * means Significant at 5 %

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Table 6: Response of NPKHA and lime on biomass data

| Treatment | Stem girth | Root | Pod yield |
|--------------|------------|------|-----------|
| Control | 1.33 | 0.52 | 6.21 |
| NPKHA | | 0.19 | 5.26 |
| NPKHA + Lime | 2.62 | 0.6 | 6.29 |
| Lime | 2.6 | 0.27 | 6.86 |
| F-LSD (0.05) | NS | NS | ** |

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CONCLUSION

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WAP = Week after planting; NPKHA (NPK with Humic Acid) and NPKHA+Lime (NPK with Humic Acid and Lime)

Note: NS means not significant * means Significant at 5 %

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