Effect of nitrogen and potassium fertilization on the yield and quality of *Momordica charantia* fruits

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Summary

Nitrogen as ammonium nitrate in three doses: of 100, 200 and 300 kg/acre and potassium as sulphate in graded doses of 50 and 100 kg/acre were added using side dressing to *Momordica charantia* to assess their effects on fruit yield and active constituents.

Nitrogen alone in graded doses increased the fruit production up to 200 kg of ammonium nitrate/acre, also all doses of potassium increased fruit production proportionally to doses. The highest number of fruits was produced with use of the combined medium nitrogen dose and high potassium doses.

The obtained data revealed that higher fruit number with higher fresh and dry weight could be obtained by adding nitrogen at 200 kg/acre with potassium at a rate of 100 kg/acre. Arbor or vineyard like method of cultivation gave more fruits with higher fresh and dry weights than normal method of cultivation. Polypeptide in immature fruits increased by nitrogen till 200 kg/acre and the combination of medium dose of nitrogen and any rate of potassium produced the highest polypeptide concentration. The same treatment combination has similar effect on cucurbitacins in immature fruits.

*Key words: Momordica, charantia, nitrogen, potassium, methods, cultivation, polypeptide, cucurbitacins*

INTRODUCTION

*Momordica charantia* is a climber belonging to cucurbitaceae family. The plant is cultivated throughout tropics, particularly in India, China, East Africa, Central and South America. It is occasionally grown as an ornamental creeper, but more commonly for use of the unripped fruit as a vegetable. The fruit has a number of different local names; bitter gourd, bitter melon, balsam pear cundeamor, karela (India) carilla or goo-fash (Jamaica).
In addition to its major use as an antidiabetic agent, karela has been used in India and Sri Lanka as a tonic, emetic and laxative [17]. Both the cultivated and wild forms are used for this purpose [4]. In south and central America cerasee fruit or tea is used in diabetes, colds and fevers, stomach aches constipation in children and abortion induction [1].

Traditional Chinese medicine uses its fruit, seeds, vines and leaves in gastroenteritis, diabetes, tumours, and some infection [31]. When used as an antidiabetic remedy, karela juice prepared by crushing and straining the unripe fruit (ca. 50 ml) is taken once or twice a day. On the other hand, cerasee is taken as a decoction or tea (hot water extraction) from the aerial part of the plant free of fruit [4].

In Egypt, two species of *Momordica*: *M. Charantia* and *M. balsamina* were introduced in a study dealing with phytochemical and pharmacological activities, [14, 10-11]. Recently a pharmacological work was conducted [25].

The plant is cultivated in a large scale to provide the requirement of one of pharmaceutical companies that will produce diabetes medicine.

Since early 1960s, a number of phytochemicals have been isolated from *Momordica charantia* fruit, seeds and whole plant. In general, the plant contains cucurbitacins saponins, protein and charantin, a steroidal glycoside responsible for the antidiabetic activity with insulinomimetic polypeptide called insulin p (11 k Dalton).

Because agricultural treatment of this plant was not found so far, the aim of this study was to highlight some agricultural treatments that may maximize the yield along with its medical value.

Nitrogen fertilization favours the development of the aerial parts over roots and consequently the promotion of flowering and fruiting of many crops. In a plant with bitter gourd its huge vegetative growth needs high amounts of nitrogen to cover its requirements. Many investigations reported the role of nitrogen on different plants with varieties of active ingredients: on volatile oils of astragon, origanum and thymus [8], on chamomile [20], on ginkgo seedlings [29] and on kaempferia galanga [12].

Potassium is an important element in plant metabolism, promoting carbohydrates synthesis. In many cases such promotion is observed only at selectively low potassium levels. An antagonistic relationship between nitrogen and potassium as related to dry weight of *Echinacea* was noted [26]. In addition to the effect of two elements on fruit production, two methods of cultivation were tried: normal method, creeping and the other applying vine yard or arbor used as a scaffold to make the plant climb.

**MATERIALS AND METHODS**

Seeds of bitter gourd raising from seeds originated from Bornträger (Germany) were obtained in Department of Cultivation and Production of Medicinal and Aromatic Plants, National Research Centre Dokki.
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Seeds were sown directly in the soil on 3 March 2004 and 7 March 2005 with row spacing of 60 cm and 1 m spacing between plants on rows.

**Fertilization experiment**

The experimental area was divided into 2 x 2 m plots. Each plot consisted of 3 rows, in which 3 replicates were conducted according to one treatment. Phosphorus was added to all treatments in a dose of 100 kg/acre as calcium super phosphate (15.5% of P$_2$O$_5$). The used fertilizers were as follows:

- nitrogen as ammonium nitrate (33.5% N) in rates of 0, 100, 200, or 300 per acre (N$_0$, N$_1$, N$_2$, and N$_3$);
- potassium as potassium sulphate (48% K$_2$O) in doses of 0, 50 or 100 kg/acre (K$_0$, K$_1$, and K$_2$).

The soil was analyzed and its physico-chemical properties were carried out according to Chapman and Pratt method [6]. The results were as follows: coarse sand, 5.45, fine sand 17.18, silt, 35.59 and clay 39.19%, in medium texture. The chemical analysis of 100 g of soil was as follows:

\[
\begin{align*}
\text{CO}_3^- & : 1.2 \text{ mg} \\
\text{Cl}^- & : 52.63 \text{ mg} \\
\text{Ca}^{++} & : 21.94 \text{ mg} \\
\text{available P2O5} & : 625 \text{ mg} \\
\text{available N} & : 122.3 \text{ mg} \\
\text{available K} & : 266 \text{ mg} \\
\end{align*}
\]

The fertilizers were added in two portions: first after 45 days of cultivation and the second after following 45 days.

The fruits were collected every month. The summation of fruits throughout the season for each treatment was calculated and compiled in Table 1.

**Table 1**


<table>
<thead>
<tr>
<th>Treatment</th>
<th>2004</th>
<th></th>
<th></th>
<th>2005</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of fruit in thousand/acre</td>
<td>weight of fresh fruits in ton/acre</td>
<td>weight of dry fruits in ton/acre</td>
<td>No. of fruit in thousand/acre</td>
<td>weight of fresh fruits in ton/acre</td>
<td>weight of dry fruits in ton/acre</td>
</tr>
<tr>
<td>N (K)</td>
<td>N</td>
<td>0k</td>
<td>50k</td>
<td>100k</td>
<td>0k</td>
<td>50k</td>
</tr>
<tr>
<td>0</td>
<td>89</td>
<td>112</td>
<td>125</td>
<td>10</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>100</td>
<td>122</td>
<td>162</td>
<td>186</td>
<td>12</td>
<td>16</td>
<td>19</td>
</tr>
<tr>
<td>200</td>
<td>165</td>
<td>168</td>
<td>200</td>
<td>15</td>
<td>17</td>
<td>18</td>
</tr>
<tr>
<td>300</td>
<td>129</td>
<td>136</td>
<td>134</td>
<td>12</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>L.S.D.</td>
<td>N</td>
<td>4.6</td>
<td>1.31</td>
<td>0.14</td>
<td>4.3</td>
<td>1.22</td>
</tr>
<tr>
<td></td>
<td>K</td>
<td>4.01</td>
<td>0.88</td>
<td>0.11</td>
<td>4.05</td>
<td>0.75</td>
</tr>
<tr>
<td></td>
<td>N+K</td>
<td>7.8</td>
<td>1.66</td>
<td>0.17</td>
<td>8.03</td>
<td>1.54</td>
</tr>
</tbody>
</table>
Methods of cultivation

Two methods of cultivations were adopted. In the first one, the plants were grown on about two-meter-long iron stand with holes in its top. There was a kind of wire going through it, which made plants climb. The stands were buried from its lower edge in the soil. In the second method the plants were left to creep on the wide rows of the plot. In this method the fruits formed on the surface of the soil, but with arbor method, the fruits are hanged on the stand or wire. The fertilizer treatment adopted here is $N_{200}K_{100}$.

Fruits were collected every month. Their characteristics was presented in Table 2.

Table 2.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Polypeptide (to dry mass)</th>
<th>Cucurbitacins (to dry mass)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0k</td>
<td>50 k</td>
</tr>
<tr>
<td>N 0</td>
<td>3.85</td>
<td>4.00</td>
</tr>
<tr>
<td>N 100</td>
<td>4.53</td>
<td>5.77</td>
</tr>
<tr>
<td>N 300</td>
<td>4.59</td>
<td>4.84</td>
</tr>
<tr>
<td>L.S.D. N</td>
<td>0.29</td>
<td></td>
</tr>
<tr>
<td>L.S.D. K</td>
<td>0.23</td>
<td></td>
</tr>
<tr>
<td>L.S.D. N+K</td>
<td>0.38</td>
<td></td>
</tr>
</tbody>
</table>

The effect of stage of fruit ripening

To correlate fruit size at different stages with different chemical components, 200 flowers from different plants in control treatment that appeared at the same time were marked. The formed fruits from the marked plants were collected, weighed and chemically analyzed at intervals of one week, for four weeks.

The following growth parameters were measured for the fruits collected in the three experiments:
1. number of fruits per plant and acre;
2. weight of fresh fruits per plant and acre;
3. polypeptide in fruits determined according to Khanna et al. [15];
4. cucurbitacins determined according to Attard and Scicluna-Spiteri [2].

Data were subjected to statistical analysis according to Duncan [9] with use of computer program costar (PIF 1990).
RESULTS

First experiment: effect of fertilization on growth parameters

1-1 Number of fruits

Table 1 compiles the growth parameters studied in two growth seasons. Nitrogen alone in different doses increases the production of fruits until 200 kg/acre of ammonium nitrate is achieved. The higher nitrogen dose (300 kg/acre) of ammonium nitrate did not give proportional fruit number. In the second season the same trend of the first one was obtained, however, with low values.

Potassium increased number of fruits from 89 in untreated plants to 112 and 125 fruits (in thousand) for K₁, and K₂, respectively. The highest number of fruit was attained when combining nitrogen in its medium dose with higher potassium rate (N₂K₂). The number of fruits was 200 and 196 (in thousand) in two successive seasons with mean of 198 (in thousand) fruits in the two seasons. On the other hand, higher dose of nitrogen (N₃) combined with any potassium dose had no significant effect on fruit number compared to nitrogen and potassium added separately in their higher rates, N₃ or K₂.

1-2- Weight of fresh and dry fruits

Nitrogen promoted the production of fruits per unit area until 200 kg/acre. The third dose (300 kg) produced fruit yield smaller than the second rate (200 kg).

It was found that bitter gourd responded well to potassium fertilization. Weight of fresh and dry fruits increased along with doses of potassium added. The interaction between nitrogen and potassium showed synergistic effect in which the treatment of N₂K₂ is the best one in the first season while the treatment of N₁K₂ was the optimum in the second one.

On the basis of the data showed in Table 1 it could be concluded that the highest number with higher weights of fresh and dry fruit could be obtained by adding either nitrogen in 100 or 200 kg/acre or potassium at a rate of 100 kg/acre. The data obtained in the two seasons showed the same trend.

Second experiment: methods of cultivation

Two methods of cultivation were conducted to study their effect on fruit production. Table 2 presents the data obtained in two seasons. It is noticed clearly that *Momordica* growing on arbor gave more fruits (in thousand) than plants left to creep (normal system) on rows. The number of fruits collected through the fruiting stage from June to November in each season was 81 against 133 fruits.
(in thousand) in normal cultivation and arbor methods, respectively, while in the second season it was 77.3 and 125. The maximum fruits production was obtained in August and September with normal cultivation method, but was shifted to September and October with plants grown on arbor.

Regarding to fresh and dry weights of fruit, it is clearly noticed that plants grown on arbor produced heavy weight or biomass which depends on higher number of gained fruits. The fresh weight of fruits collected through the season of growth was 11.4 tons in normal method vs 18 tons for arbor method, respectively. The dried weight of the total yield of fruits with two methods of cultivation showed the same pattern as fresh weight production.

The effect on stage of fruit ripening

Dealing with fruit growth stages, Table 3 demonstrates a sharp increase in fruit length until the second week, then steadily risen the fruit length until the fourth week in which it reached apex. Mean fruit weight (200 fruit) illustrates steadily increase until the third week and slight increase noticed in the fourth week.

Table 3

Effect of methods of cultivation on fruit parameters of *Momordica charantia*

<table>
<thead>
<tr>
<th>Treatment</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. of fruit in thousand/acre</td>
<td>weight of fresh fruits in ton/acre</td>
</tr>
<tr>
<td>normal method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>6</td>
<td>0.7</td>
</tr>
<tr>
<td>July</td>
<td>13</td>
<td>2.0</td>
</tr>
<tr>
<td>August</td>
<td>20</td>
<td>2.5</td>
</tr>
<tr>
<td>September</td>
<td>16</td>
<td>2.5</td>
</tr>
<tr>
<td>October</td>
<td>14</td>
<td>2.0</td>
</tr>
<tr>
<td>November</td>
<td>12</td>
<td>1.4</td>
</tr>
<tr>
<td>Total</td>
<td>81</td>
<td>11.4</td>
</tr>
<tr>
<td>arbor method</td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td>8.0</td>
<td>0.9</td>
</tr>
<tr>
<td>July</td>
<td>16.0</td>
<td>2.4</td>
</tr>
<tr>
<td>August</td>
<td>17.0</td>
<td>3.7</td>
</tr>
<tr>
<td>September</td>
<td>34.0</td>
<td>5.0</td>
</tr>
<tr>
<td>October</td>
<td>28.0</td>
<td>3.7</td>
</tr>
<tr>
<td>November</td>
<td>20.0</td>
<td>2.3</td>
</tr>
<tr>
<td>total</td>
<td>133.0</td>
<td>18.0</td>
</tr>
</tbody>
</table>
Chemical investigation

First experiment

The polypeptides in fresh immature fruits treated in different ways were estimated. The data compiled in Table 2 reveal that potassium at higher rates increased the polypeptide percentage.

Nitrogen increased the content of polypeptide in the immature fruit with its gradual doses over the untreated plants. However, higher rates of nitrogen did not produce the highest content of polypeptide. The same trend was observed in weight of fresh and dry fruits.

The interaction of nitrogen and potassium produced highest polypeptide content, especially the treatments with use of $N_2K_2$, $N_2K_1$ or $N_1K_2$, meaning that medium rates of nitrogen when combined with any rate of potassium is an ample ratio to promote the polypeptide synthesis.

Important active ingredients characteristic for the cucurbitaceae family are cucurbitacins: highly oxygenated, mainly tetracyclic triterpene, assayed in immature fruits. Higher levels of cucurbitans were attained with use of high potassium rates; however, lower doses produced significant increase, as compared to those with no potassium added. Nitrogen alone in its graded dose produces an increase of previously unfertilized plants, as follows: 13.4, 54.3 and 19.2% for $N_1$, $N_2$ and $N_3$ over No, respectively, where the medium dose of nitrogen was the effective rate.

The combined elements as $N_1$ or $N_2$ with $K_2$ treatments synthesized higher cucurbitacin content. The other treatments did not produce assumed proportional increase.

Third experiment: the effect of fruit stages on chemical constituents

Considering fruit stages and different active principles content, Table 4 presents their relationship. Level of polypeptide is nearly constant in four weeks of fruit stages. Cucurbitacins show maximum content in second and third week and then decreases.

In order to obtain higher fruit yield with higher active ingredients content, nitrogen was added to plants at a rate of 200 kg/acre combined with potassium at a dose of 100 kg/acre. The fruits must be collected after 2 weeks from flowering.

Table 4.
Growth parameters and chemical constituents of fruits at different stages of *Momordica* fruit (2004-2005).

<table>
<thead>
<tr>
<th>season 2004</th>
<th>2005</th>
<th>chemical constituents (mean of two seasons)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>fruit length (cm)</td>
<td>fruit weight (gm)</td>
</tr>
<tr>
<td>1st week</td>
<td>4.0</td>
<td>14</td>
</tr>
<tr>
<td>2nd week</td>
<td>7.0</td>
<td>64</td>
</tr>
<tr>
<td>3rd week</td>
<td>7.0</td>
<td>96</td>
</tr>
<tr>
<td>4th week</td>
<td>7.0</td>
<td>110</td>
</tr>
<tr>
<td>mean of 200 fruits</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
DISCUSSION

Tracing the literature, no agricultural treatments were performed except some Indian experiments on different *Momordica* species dealing with effect of growth regulators and correlation between fresh weight of fruits and seed content of spine gourd. Some authors [22, 28] reported the effect of drip and surface irrigation and their effect on yield of bitter gourd. In a field experiment it was reported that ascorbic acid content in fruits of *M. charantia* showed 12% and 5% increase at all stages by spraying with 0.02 and 0.04 m/l of Zn, respectively. They also added that there was 33% increase in fruit yield by spraying Zn at 0.02 mg/l over the plants which were not sprayed with Zn.

One investigation dealt with manuring *M. charantia* with organic and mineral fertilization and their effects on total yield, marketable yield and size of fruits. This research concluded possibility of achieving a reasonably good yield by basal applicant of dry cow dung, top dressing with poultry manure and drenching cow dung slurry at fortnightly intervals. However, the study did not mention the percentage of nitrogen in all the organic forms added. The suitable inorganic fertilization was at the ratio of 70:25:25 NPK kg/ha, which differs from those added in the present investigation [18, 24].

A subject related to some extent to our present study revealed that fruit number per plant had the highest direct contribution towards the yield followed by fruit length and diameter, whereas average fruit weight had the highest indirect contribution towards yield [16, 27].

Dealing with the occurrence and accumulation of polypeptide and cucurbitacins content as well as the relation between them and fertilization nothing was reported in previous work concerning *Momordica charantia* or other plants bearing cucurbitacins. The present study is first report concerning this matter.

With other plants, for instance forage plants, Aydin and Uzun [3] reported that nitrogen fertilization slightly decreased the crude protein concentration in the forage dry matter from 120 g/kg in non fertilized control to 103–116 g/kg in plots fertilized only with nitrogen. This effect can be explained by the observation that nitrogen fertilization resulted in a decline of the legume proportion from 47% in non-fertilized control to 5% with the use of highest nitrogen rate. The protein and their degradable products like polypeptide concentration in legume plants were always considerably higher than that in grasses and other plant species.

REFERENCES

Effect of nitrogen and potassium fertilization on the yield and quality of *Momordica charantia* fruits

Wpływ nawożenia potasem i azotem na plon i jakość owoców *Momordica charantia*

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**Streszczenie**

Badano wpływ nawozów azotowych i potasowych na masę owoców *Momordica charantia* i zawartość substancji aktywnych. W celu zbadania wpływu takiego nawożenia na liczbę owoców i zawartość substancji aktywnych podawano w pobliżu korzeni *Momordica charantia* azotan amonowy w trzech dawkach: 100, 200 i 300 kg/akr i siarczan potasu w dawkach rosnących od 50 do 100 kg/akr. Azot stosowany samodzielnie w rosnących dawkach zwiększył ilość owoców przy zastosowaniu dawki 200 kg azotanu amonowego na akr. Wszystkie dawki potasu zwiększyły plon owoców proporcjonalnie do dawki. Najwięcej owoców otrzymano przy zastosowaniu połączonej średniej dawki azotu i wysokich dawek potasu. Otrzymane wyniki dowiodły, że większą ilość owoców (a także większą masę świeżych owoców i większą suchą masę) można osiągnąć, stosując 200 kg azotu na akr równocześnie ze 100 kg potasu na akr. Uprawa w rzędach lub metodą winnicową pozwoliła uzyskać więcej owoców o większej masie świeżej i większej masie suszu niż przy stosowaniu metody tradycyjnej. Dzięki nawożeniu azotem zawartość polipeptydów w niedojrzałych owocach została podwyższona aż do 200 kg/akr. Kombinacja średniej dawki azotu i dowolnej dawki potasu dała największe stężenie polipeptydów. Podobny efekt zastosowania tej kombinacji został odnotowany w niedojrzałych owocach innych dyniowatych.

Słowa kluczowe. *Momordica charantia*, azot, potas, metoda, uprawa, polipeptydy, dyniowate