EFFECT OF ORGANIC MANURE SOURCE AND BIOFERTILIZER TYPE ON GROWTH, PRODUCTIVITY AND CHEMICAL COMPOSITION OF JEW’S MALLOWS \((\textit{Corchorus olitorious} \text{ L.})\) PLANTS

GHONEIM, I.M. and S.M. EL-ARABY

Vegetable Crops Dept., Fac. Agri., Alex. Univ.

ABSTRACT

Two field experiments were carried out during the summer seasons of 2001 and 2002 at the Experimental Station Farm of the Faculty of Agriculture, Alexandria University, at Abeis, to study the effects of four treatments of organic manure (unmanured, chicken, compost and cattle) and three biofertilizer treatments (uninoculated, Halex 2 and Nitrobein) on vegetative growth, yield potential and chemical constituents of jew’s mallow plants (cv. Balady) grown in clay loam soils. The results, generally, indicated that organic manures, irrespective of the used source, enhanced vegetative growth characters; expressed as plant height, leaf area plant\(^{-1}\), and fresh and dry weights of leaves and plant weights. Chicken manure was the most effective in this respect, followed by compost. Yield potentials, expressed as fresh weight of first and second cuttings, and total fresh \((\text{kg/m}^2)\) and dry yields \((\text{g/m}^2)\) were increased due to the application of various organic sources, particularly chicken manure. In addition, leaves contents of chl. (a), chl. (b), chl. (a+b), N, K, Ca and Fe were positively and significantly affected by organic manures. Chicken manure exceeded both compost and cattle manures in the terms of mineral contents and photosynthetic pigments. Inoculation of seeds with the biofertilizer Halex-2 or Nitrobein, greatly, improved vegetative growth characters and yield potentials and increased leaves chemical contents. Halex-2 appeared more effective than
Nitrobein in this respect. The most efficient treatment combination was found to be that of chicken manure in addition to Halex-2 biofertilizer which gave more vigorous growth, better yield potentials, as well as higher leaves chemical contents.

INTRODUCTION

Jew’s mallow (Corchorus olitorious L.) is a popular summer leafy vegetable crop grown in Egypt. Its green leaves, fresh or dry are used in soups and stews, which have a refreshing flavour. Its contents of Ca, P, K, Na and Fe elements; A, B₁, B₂, B₅ and C vitamins; and folic acid are well known.

Nitrogen requirements of vegetable crops, particularly those of leafy ones, are relatively high; but the continuous and excessive applications of mineral N fertilizer create pollution of agro-ecosystem and lead to some adverse effects on soil fertility (Fisher and Richter, 1984). Organic fertilization was found to provide the plants with the necessary macro and micro-elements in available forms through mineralization process (Marschner, 1994). In addition, it improved the physio-chemical properties of the soil and had a profoundly effect on the activity of microflora organisms (Mengel and Kirkaby, 1987; El-Nadi et al., 1995). The growth, yield potential and chemical composition of multifarious vegetable crops were noticed to be enhanced by organic fertilization (Moussa, 1993; Ahmed et al., 1997; Abd El-Megeed et al., 2000; Mahmoud et al, 2000; Mohamed and Gabr, 2002).

Furthermore, increased attention has been recently directed towards the utilization of biofertilizers in order to substitute completely or supplement partially the chemical N fertilizer and to mitigate the adverse impacts of mineral N fertilization on human health and environment (Ahmed et al., 1997; EL-Gizawy, 1998; Niel, 2001; EL-Zieny et al., 2001).

Unfortunately, in Egypt, some little informations are available regarding responses of jew’s mallow to organic and bio-fertilization. Accordingly, this study was conducted to investigate the impacts of fertilization with different biofertilizer types and organic manure sources.
on vegetative growth, productivity and chemical constituents of jew's mallow.

MATERIALS AND METHODS

The main effects of some organic and biofertilizer types as well as their interactions on growth, yield and chemical composition of jew's mallow cv. Balady were investigated through two field experiments; executed at the Experimental Station Farm (at Abeis), Fac. Agric., Alex. Univ.; during the two summer seasons of 2001 and 2002.

Organic fertilizer treatments contained three different forms; cattle manure, chicken manure and compost as well as the untreated (control) treatment. Biofertilizer treatments included seed inoculation with two variant types of biofertilizers; Halex-2 and Nitrobein; as well as the uninoculated control. There were twelve treatment combinations in total. The organic manure of cattle and chicken were supplied by the Experimental Farms of Animal and Poultry Production, Fac. Agric., Alex. Univ., orderly. Meanwhile, the organic compost manure was obtained from the Factory of Organic Fertilizers located at Abeis, Alex. Governorate. The biofertilizer Halex-2; a mixture of non-symbiotic N-fixing bacteria of the genera Azotobacter, Azospirillum and klebsiella; was obtained from the Biofertilization Unit, Plant Pathology Department, Fac. Agric., Alex. Univ.; whereas, the biofertilizer Nitrobein; a single strain of non-symbiotic N-fixing bacteria of the genus Azospirillum; was obtained from the Biofertilization Unit, Ministry of Agriculture, Egypt.

Preceding the initiation of each experiment, soil samples at 25cm depth were collected from each experimental site and analyzed, according to Page et al. (1982). The results of the analyses are given in Table (1). The chemical properties of the used organic manure sources are presented in Table (2).
Table 1. Some important physical and chemical properties of the experimental sites in 2001 and 2002 seasons.

<table>
<thead>
<tr>
<th>Physical properties</th>
<th>Chemical properties</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand (%)</td>
<td>Silt (%)</td>
</tr>
<tr>
<td>2001</td>
<td>22.1</td>
</tr>
<tr>
<td>2002</td>
<td>21.7</td>
</tr>
</tbody>
</table>

Table 2. Chemical constituents of cattle, chicken and compost manures in 2001 and 2002 seasons.

| Season | 2001 | | 2002 | | |
|--------|------|----------------|------|----------------|------|----------------|------|----------------|------|----------------|
|        | Source of organic manure | | Source of organic manure | | |
|        | Cattle | Chicken | Compost | Cattle | Chicken | Compost | |
| Moisture | % | 67.80 | 20.28 | 29.30 | 70.20 | 15.95 | 22.15 |
| Organic carbon | % | 18.62 | 38.40 | 19.95 | 18.12 | 37.92 | 20.88 |
| Organic matter | % | 50.12 | 60.42 | 49.34 | 50.28 | 62.14 | 49.80 |
| N | % | 1.10 | 3.21 | 1.28 | 1.08 | 3.12 | 1.38 |
| C/N ratio | 1:16.93 | 1:11.96 | 1:15.82 | 1:16.77 | 1:12.15 | 1:15.13 |
| PH | 9.11 | 8.03 | 8.22 | 9.02 | 7.88 | 8.12 |
| EC | dsm⁻¹ | 5.76 | 4.62 | 4.88 | 5.68 | 4.23 | 4.72 |
| P | % | 0.60 | 2.02 | 1.42 | 0.80 | 1.52 | 1.38 |
| K | % | 1.42 | 1.66 | 1.54 | 1.52 | 1.78 | 1.68 |
| Fe | ppm | 3200 | 4115 | 3012 | 3110 | 4088 | 2980 |
| Mn | ppm | 126 | 168 | 134 | 122 | 162 | 128 |
| Zn | ppm | 48 | 188 | 96 | 52 | 177 | 68 |
| Cu | ppm | 12 | 35 | 19 | 10 | 32 | 14 |
| Ca | % | 7.22 | 6.15 | 5.82 | 6.98 | 6.08 | 5.99 |

Note: 1m³ cattle, chicken and compost manure weighed 700, 575 and 760 kg, orderly.

Cattle manure was utilized at the recommended dose of 30 m³ fed⁻¹ and the equivalent amounts from the chicken and compost manures, according to their N content and weight of 1 m³ of each, were calculated in the two seasons, as appears in Table (3).
Table 3. The used amounts of the three sources of organic manures in 2001 and 2002 seasons.

<table>
<thead>
<tr>
<th>Source of organic manure</th>
<th>Amount of organic manure (m³ fed⁻¹)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001 season</td>
</tr>
<tr>
<td>Cattle</td>
<td>30.00</td>
</tr>
<tr>
<td>Chicken</td>
<td>12.52</td>
</tr>
<tr>
<td>Compost</td>
<td>23.75</td>
</tr>
</tbody>
</table>

All organic fertilization treatments were incorporated into the soil, 15 days before seed sowing. Halex-2 and Nitrobein biofertilizers were utilized at the rate of 200 and 500g fed⁻¹, respectively, according to the recommendations of each type. Seed inoculation was performed just before sowing by dressing in a suspension of the biofertilizer type using Arabic gum solution (40%) as an adhesive agent at the rate of 3ml/100 g seeds. Uninoculated seeds were treated by Arabic gum solution only. Seeds were sown, at the rate of 12 kg fed⁻¹ on April 22, 2001 and April 18, 2002.

The experimental layout was a split-plot system in a randomized complete blocks design with three replications. Organic manure sources comprised the main plots; while, the biofertilizer treatments were included in the sub-plots. Each experimental unit included a basin of 3x3.5 m with a total area of 10.5m². Mineral fertilizers were not used during the two experiments and all recommended agro-managements, necessary for the commercial jew's mallow production, were followed. Harvesting included two cuttings that were executed at 50 and 75 days from seed sowing.

**Data Recorded**  
**Vegetative Growth Characters**

A random sample of 20 plants from each experimental unit was carefully taken during the first cutting. The vegetative measurements of plant height (cm), leaf area plant⁻¹ (cm²), leaves fresh and dry weights plant⁻¹ (g), and fresh and dry weights plant⁻¹ (g) were recorded.
Yield Potential

From each sub-plot, the plants growing in one meter square, in each cutting, were harvested and weighed (fresh weight) then dried in a forced air oven at 70°C till the weight became constant. The total fresh (kg) and dry (g) weights in the two cuttings were recorded.

Chemical Composition.

A random leaf sample, from each sub-plot during the 1st cutting only in the second experiment, was collected, washed with tap water and rinsed three times with distilled water, for chemical determinations. Concentrations of chlorophyll (a) and (b) were determined as outlined by Witham et al. (1971). Concentration of total chlorophyll was obtained by summation. Nitrogen concentration was determined using microkjeldahal procedure. Phosphorus concentration was estimated, using ammonium molybedate stannous chloride method (A.O.A.C., 1992) and, K concentration was determined, using flame photometer (Black, 1965). Calcium and Fe concentrations were estimated, using Perken-Elemer Atomic Absorption Spectrophotometer Model 305 B as described in A.O.A.C. (1992).

Appropriate analyses of variance on data of each experiment were performed, using Costat Software (1985). Comparisons among the means of the various treatment combinations were carried out, using the revised least significant difference test at p=0.05, illustrated by El-Rawy and Khalf- Allah (1980).

RESULTS AND DISCUSSION

I Vegetative Growth Characters

Fertilization with the organic manure, irrespective of the used source, was significantly associated with higher averages of plant height, leaves area plant⁻¹, leaves fresh and dry weights plant⁻¹, and fresh and dry weights plant⁻¹ than the unmanured (control) treatment, in 2001 and 2002 seasons (Table 4). However, some exceptions were noticed in the area plant⁻¹, in 2001 and 2002 seasons, and leaves dry weight, in 2001 season, as the differences between the application of cattle manure and the control treatment were found too small to be significant. The comparisons among the mean values of the studied vegetative traits, generally,
indicated that the highest mean values were gained as a result of chicken manure application, followed by compost and finally by cattle manure. Such a noticed positive effect of organic manures on vegetative growth characters could be due to that the available amounts of macro and micro-elements of plants in the soil were relatively low, as appeared from the results of soil analyses of the used experimental sites (Table 1). In addition, the presented analyses of manure sources in Table (2), clearly, showed that chicken manure had relatively higher nutrient contents, resulted in more efficient effects on the studied characters than the other manure sources. The detected enhancing effects of the used organic manures on the studied vegetative characters could be related to the decomposition of the organic manures and the slow release of nutrients in available forms that were sufficient to meet the requirements of growing plants. Improving effects of organic manures on physical, chemical and biological properties of soils were suggested (Mengel and Kirkaby, 1987) to support the absorption of nutrients and accelerate the photosynthesis process to go forward with an eventual increase on the vegetative growth. The obtained results matched well with those of Moussa (1993) and Ahmed et al (1997), who reported that the application of farmyard manure to jew's mallow plants increased significantly plant height, number of leaves plant$^{-1}$, and fresh and dry weights of leaves and stems plant$^{-1}$.

Inoculation of jew's mallow seeds, before sowing, with the biofertilizer Halex-2 or Nitrobein was responsible for significant increases on plant height, leaves area plant$^{-1}$, leaves fresh and dry weights plant$^{-1}$, and fresh and dry weights plant$^{-1}$ over the uninoculated control, in both seasons (Table 4). The only exception was in 2002 season; where, the inoculation with the biofertilizer Nitrobein did not reflect any significant effect on leaf area plant$^{-1}$. The inoculation with the biofertilizer Halex-2 was associated with the highest mean values for most of the studied vegetative growth characters. However, the differences between Halex-2 and Nitrobein were not found significant. The beneficial effects of biofertilizers on vegetative growth traits of jew's mallow may be related to the promotion effects of the non-symbiotic N$_2$-fixing bacteria on morphology and / or physiology of the root system; which, perhaps,
resulted in a more efficient utilization of available nutrients in the soil, favoring the vegetative growth to go more forward. Jagnow et al. (1991) and Noel et al. (1996) pointed out that the non-symbiotic N$_2$-fixing bacteria, *Azotobacter* and *Azospirillum*, produced adequate amounts of IAA, gibberellins and cytokinins, and synthesized some vitamins. Moreover, they increased the surface area per unit root length and enhanced the root hair branching, with an eventual increase on the uptake of nutrient and water from the soil. Carletti et al. (1996) demonstrated that the plants, inoculated with *Azospirillum*, displayed an increase on total root length by 150%, compared to the uninoculated control. Furthermore, Apte and Shende (1981) reported that the inoculation substances may change the microflora in the rhizosphere and affect the balance between harmful and beneficial organisms. Similar findings were recorded by Ahmed et al. (1997), who indicated that the inoculation with *Azotobacter* increased significantly the fresh and dry weights of leaves and stems as well as plant height and number of leaves for jew’s mallow plants. El-Gizawy (1998) stated that leaves dry weight of jew’s mallow was significantly increased as a result of the inoculation with *Azotobacter*, *Azospirillum* and *klebsiella*. Niel (2001) reported similar results on spinach.

The interaction effects between the various forms of organic manure and biofertilizer on the fresh weight of leaves plant$^{-1}$, and the plant fresh and dry weights were found significant, in both seasons (Table 4). Plant height, leaf area plant$^{-1}$ and leaves dry weight plant$^{-1}$, however, appeared insignificant, in both years. The heaviest significant leaves fresh weight plant$^{-1}$ was gained when the chicken manure and the biofertilizer Nitrobein were coupled together. Meanwhile, the best significant result for the fresh weight plant$^{-1}$ was attained due to the combined application of chicken manure with the biofertilizer Halex-2, in both seasons. It was also noticed that the highest mean values of dry weight plant$^{-1}$ were recorded as a result of the application of chicken manure in the presence of Halex-2 or Nitrobein. The stimulatory effects of biofertilization with Halex-2 or Nitrobein in combination with chicken manure, rather than cattle manure or compost, were probably due to the relatively higher contents of nutrients (Table 2), which were positively reflected on soil structure, aeration, water
retention and nutritional status (Kaloosh and Koreish, 1995) as well as to the beneficial effects of a biofertilizer on stimulating plant growth as previously mentioned. Such favorable effects seemed to be coupled together and reflected as eventual increases on leaves fresh weight plant$^{-1}$ and fresh and dry weights plant$^{-1}$.

II Yield potential

Data arranged in Table (5) exhibited that organic manuring, irrespective of the used source, significantly, augmented the fresh yield of 1$^{\text{st}}$ and 2$^{\text{nd}}$ cuttings as well as total fresh and dry yields, relative to the unmanured (control) treatment, in both 2001 and 2002 seasons. The only noticed exception was on the fresh weight of 1$^{\text{st}}$ cutting in 2001 season; where, the difference between cattle manure and control was not found significant. Obviously, the application of chicken manure produced significantly the highest fresh yield of 1$^{\text{st}}$ cutting, and total fresh and dry yields; in both seasons. Meanwhile, the application of cattle manure gave significantly the highest fresh yield of 2$^{\text{nd}}$ cutting. These results might be discussed on the base that chicken manure is known to be more easily to decompose than cattle manure (Ismail et al., 1988); which, in turn, devoted more available nutrients for the plants to grow quickly and better with chicken than with cattle manure. Reversaly, the slow decomposition of cattle manure, probably, offered sufficient nutrients for the plants to express their best performance on the fresh yield of 2$^{\text{nd}}$ cutting. The enhancing effects of organic manure sources on yield potential might be referred to the noticeable increase on plant height, fresh and dry weights plant$^{-1}$ and leaf area plant$^{-1}$, as indicated in Table (4). Similar results were generally reported by Moussa (1993) and Ahmed et al. (1997).

Seeds inoculation of jew's mallow with the biofertilizer Halex-2 or Nitrobein exerted positive remarkable influences on the fresh yield of 1$^{\text{st}}$ and 2$^{\text{nd}}$ cuttings, and total fresh and dry yields; relative to the uninoculated treatment, in both seasons (Table 5). The more obvious effectiveness of Halex-2 than Nitrobein on all aforementioned traits was
noticed, in both years with only one exception in the case of fresh yield of 2nd cutting in 2002 growing season. The more promoting influences of Halex-2 than Nitrobein might be explained on the basis that Halex-2 is a multi-inoculant containing three different genera of non-symbiotic N fixing bacteria; *Azotobacter*, *Azospirillum* and *Klebsiella* (Gabr et al., 2002); while, Nitrobein is a sole inoculant containing a non-symbiotic N-fixing bacteria of the genus *Azotobacter* (El-Zieny et al., 2001). The obtained results confirmed the previous findings of Ahmed et al. (1997). El-Gizawy (1998) stated that the fresh yield of jaw’s mallow increased by 40% due to inoculation with the three different isolates; *Azotobacter* A104, *Azospirillum* A2 307 and *Klebsiella* K 201; compared to the uninoculated (control) treatment.

The interactions of organic manure by biofertilizer source had some significant effects on yield potential of jew’s mallow plants, in both years (Table 5). Comparisons among the different treatment combinations clarified that the combination of chicken manure with Halex-2 produced the highest fresh yield of 1st cutting, and total fresh and dry yields in both seasons; while, the combination of cattle manure and Halex-2 gave the maximum fresh yield of 2nd cutting. The enhancing effects of organic manure combined with biofertilizer on yield potential might be attributed to the synergistic and supplementary effects of both bio-and-organic fertilizers on vegetative growth (Table 4) as previously illustrated.

### III Chemical Composition

Table (6) shows that the application of organic manure in the form of chicken, cattle or compost, significantly, enhanced the leaf contents of the photosynthetic pigments; chlorophyll a and b; the macroelements; N, K and Ca; and the microelement Fe; relative to the control. However, few exceptions were detected; where, the concentrations of chlorophyll b and Ca in leaves did not seem to be affected by the application of cattle and chicken manures, orderly. Leaf P content, however, did not appear to be significantly affected; whether the organic manure, in any form, was applied or not. Comparisons among the general influences of the three organic sources, clearly, indicated that the chicken manure ranked the
first, followed by cattle manure and, lastly, was the compost. The superiority of chicken manure could be attributed to its relatively high contents of nutrients, as shown in Table (2), and to its more easily decomposition than the other two sources, as reported by Ismail et al. (1988). El-Nadi et al. (1995) pointed out that chicken manure had higher contents of nutrients and a higher degree of holding water than compost. Moussa (1993) and Ahmed et al. (1997) reported similar results.

Seed inoculation of jew's mallow either with Halex-2 or Nitrobein was significantly associated with higher concentrations of photosynthetic pigments; chlorophyll a, and b; macro-elements; N, K and Ca; and micro-element Fe in leaves; than those of the uninoculated control (Table 6). Leaves P concentration, however, was not affected. Biofertilization with Halex-2 was significantly more effective than Nitrobein on all aforementioned traits; except on P content; where, their effects were similar. The obtained results agree in general with those of Ahmed et al. (1997), who reported some enhancing effects on the concentrations of N, P, K and Fe in jew's mallow leaves as a result of inoculation with biofertilizer.

Nitrogen percent in jew's mallow leaves increased from 0.24 to 0.58 as a result of the inoculation with the N$_2$-fixing bacteria of the genera Azotobacter, Azospirillum and Klebsiella (El-Gizawy, 1998).

The interaction effects between organic source and biofertilizer type on the concentrations of chlorophyll a, total chlorophyll, N, K, Ca and Mg in leaves were found significant (Table 6). Concentrations of chlorophyll (b) and leaf P content, however, were not affected. The comparisons among the various treatment combinations showed that chicken manure coupled with Halex-2 biofertilizer, significantly, gave the highest mean values for most leaf mineral contents and photosynthetic pigments. These results seemed to be compatible with those reported by Ahmed et al. (1997) regarding the combined effect of organic manure and biofertilizer on the elemental content in jew's mallow leaves.

In conclusion, the present investigation demonstrated the validity of producing jew's mallow using organic manure, particularly chicken manure at the rate of 12.58 m$^3$ fed$^{-1}$ combined with Halex-2 biofertilizer (200g fed$^{-1}$). Such treatment combination will save the high cost of mineral
fertilizers and decreases the pollution of environment as well as insures safe food.

REFERENCES


Noel, T.C.; C. Sheng; C.K. Kost; R.P. Pharis and M.E. Hymes. 1996.


The abstract in Arabic:

تأثیر مصدر السماد العضوی و نوع السماد الحوی على النمو والإنتاج والمحصول الكیمیائي للنباتات الملوخیة

إبراهيم محمد غنیم - سناء مرسی العربی
قسم الخضرا - كلية الزراعة - جامعة الإسكندرية

یجرت دراسة حقلية لمدة عامين خلال المواسم الصيفية لعامين 2001/2002، بالمزرعة التجريبية لكلية الزراعة - جامعة الإسكندرية بأسیس، دراسة تأثیر ثلاثة معاملات من التسميد الحوی (غیر ملتق، هالکس، نتروبین) تحت ثلاثة مصادر مختلفة من السماد العضوی (زرق دواجن، مخلفات مدن مکهورة وقین دواجن) بالإضافة إلى معاملة المقارنة (بدون تسمید)، وذلك على بعض صفات النمو والمحصول والمحصول الكیمیائي للثمار بالزراعة في بيئة طبيعية سائتیة.

أوضحت النتائج أن استخدام الأسمدة العضویة، بصرف النظر عن المصدر المستخدم، قد أدى إلى تحسین صفات النمو الخضري، معیراً علیه ارتفاع الکثافة والمساحة الورقیة والوزن الجاف والبیغ للثمار في كل من المواسم. وکذلك أظهرت تأثیرات تسمید الدواجن فوقوا واضحًا وکان الأثر مباعلًا في هذا الصدد. وکیل ذلك سداد المکهورة وکیل ذلك سداد الدواجن فهي استجاب للبذور المحصلیة، معبأً علیه بالمحصول الطارج لكل من الجهید اللازمة والثمار، والمحصول الكیمیائي للثمار والبیغ للمتر المربع، وذلك بالتعادل مثل کیل هذه الصفات نقطة التقطيم العضوی وکیل ذلك سداد الدواجن، بالإضافة إلى ذلك، فقد أدى التسمید العضوی على زيادة معنوية وکیل سواء الأوراق من كلوروفیل (أ) والكلوروفیل الكثی (ب) والنتروجین والبوتاسیوم والکالسیوم والحدیط، ${\text{Cd}}$، وکیل ذلك سداد الدواجن على كل من سداد المکهورة والمحصول الكیمیائي في هذا الصدد.

وقد بینت النتائج أن تلقح بذور الملوخیة بالسماد الحوی هالکس - نتروبین قد أدى إلى تحسین صفات النمو الخضري والجهید المحصولی، علیه زایدة محتوى الأوراق من كل من كلوروفیل (أ)
كلوروفيل (ب) لكلوروفيل الكلي (أ) وعناصر النتروجين والبوتاسيوم والكالسيوم والحديد، وقد تميز
السماد الحيوي هالكس-2 بتفوق واضح على النتروجين في هذا المضمار. وقد أوضحت النتائج بصورة
عمامة أن استخدام سماد الدواجن العضوي مع تلقح البذور قبل زراعتها بالسماد الحيوي هالكس-2، كانت
أكثر المعاملات العاملية كفاءة، حيث أعطت أعلى نمو خضري ومحصولي، بالإضافة إلى زيادة
المحتويات الكيماوية في الأوراق من الكلوروفيل والعناصر المعدنية.