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# Influence of biofertilizers and $GA_3$ on nutritional composition in Moringa (*Moringa oleifera* Lam.) leaves, pods and seeds

*Corresponding author's email: nimisharaj.2013@gmail.com

* Nimisha Raj Jain- PhD Research Scholar (vegetable science) former gold medalist at college of agriculture, Gwalior M.P

*Dr. Rajesh Lekhi – Professor and Head of the department, College of Agriculture, Gwalior. M.P

* Dr. R.C Jain – Principal Soil Scientist at R.A.K college of Agriculture , Sehore. M.P

## ABSTRACT

A field experiment was carried out during 2019-20 and 2020-21 at the Dryland HorticultureFarm,Sirsod, Gwalior (M.P.) to study the influence of biofertilizers and $GA_3$ on nutritional composition in Moringa leaves, pods and seeds. Application of 75% RDF+ VAM fungi + 20 ppm $GA_3$brought about maximum major, secondary and micronutrients in dry leaves, pods and seeds of Moringa. In dry leaves, N, P, K, S, Ca, Mg, Zn, Cu, Mn and B were 3.14, 70.31, 244.3, 417, 45.45, 40.71, 42.92, 0.97, 0.97 and 0.25 mg/100 g, respectively. Similarly seeds contained 3.78, 53.24 381.6, 0.069, 4.64, 63.78, 5.89, 5.83, 30.34 and 0.075 mg/100 g of N, P, K, S, Ca, Mg, Zn, Cu, Mn and B, respectively. The second best fertility levels was 75% RDF + PSB (phosphate-solubilizing bacteria) + 20 ppm $GA_3$ and then the third best fertility level was 75% RDF + PMB (phosphate-mobilizing bacteria) + 20 ppm $GA_3$ in increasing the nutrients composition in dry leaves, pods and seeds of Moringa.

**Key words:** Biofertilizers, $GA_3$, Moringa, dry leaves, pods, seeds

## INTRODUCTION

Moringa (*Moringa oleifera* Lam.)is native to the Indian subcontinent and has become naturalized in the tropical and subtropical areas around the world. Moringa tree can be used for food, medication and industrial purposes (Khalafalla *et al.*, 2010). People use its leaves, flowers and fresh pods as vegetables, while others use it as livestock feed (Anjorin *etal.*, 2010). Moringa is extensively promoted worldwide for nutrition supplementation as it is rich in protein (5-10%), in minerals (iron and calcium) and in vitamins such as vitamin C and carotene (Church World Service,2000). In view of its high nutritional value, it becomes very important as a human food as it can supplement a number of food crops. In comparison, gram for gram, Moringa has more beta-carotene than carrots (*Daucus carota*), more protein than peas (*Pisum sativa*), more vitamin than oranges (*Citrus citrii*), mor calcium than milk, more potassium than bananas (*Musa spp.*)and more iron than spinach (*Spinocea oleracea*) (Palada and Chang, 2003). Pods of Moringa are often cooked and eaten like green beans. The whole seeds are also ate green, roasted for powdered, and steamed in tea and curries (Fahey, 2005). The leaves are a very rich source of nutrients and contain the essential vitamins A, C and E. Dried or fresh leaves used in foods such as soups and porridges (Fahey, 2005). Nutritional composition of the plant plays a significant role in nutritional, medicinal and thereapeutic values (Al-Kharusi *et al.*, 2009). It was reported that nutritional content in the leaves of Moringa varies with location (Anjorin *et al.*, 2010). This was prompted the study of nutritional composition of Moringa leaves, pod and seeds under organic fertility management.

## MATERIALS AND METHODS

The field experiment was conducted during *kharif* seasons of 2019-20 and 2020-21at the Dryland Horticulture Farm, Sirsod, Gwalior (M.P.). The soil of the experimental field was clay-loam having pH 7.8, electrical conductivity 0.39 dS/m, available N, $P_2O_5$, $K_2O$, S was202, 11.16, 425, 8.89kg/ha, respectively. The rainfall received during June to December was 843 and 638 mm in both the years. The 16 treatments comprised of $T_0$-control, $T_1$-100 % RDF, $T_2$ to $T_{15}$ 75 % RDF with VAM fungi (VA-mycorrhiza) or PSB (phosphate-solubilizing bacteria) or PMB (phosphate-mobilizing mycorrhiza) or

*Azotobacter* with $GA_3$ @ 10 and 20 ppm under their different combinations. Thus treatments were laid out in the randomized block design keeping three replications. There were total 48 one-year old drumstick trees var. Bhagya planted under m x 3 m spacing. The 100 % RDF was applied @ 23:18:28 NPK kg/ha i.e. 13.8:10.8:16.8 g NPK /tree. The biofertilizers were applied @ 50 g/tree and $GA_3$ was foliar sprayed @ 10 and 20 ppm as per treatments. The drumstick tree were allowed to grow as per recommended package of practices. The periodical observations on growth and yield-attributing parameters were recorded. The major, secondary and micronutrient contents in dry leaves of Moringa were determined in the chemical laboratories as per prescribed procedures in each case. The periodical data thus obtained wore subjected to statistical computation before presenting the results. The dried powdered of Moringa leaves, pods and seeds were assessed for N, P, K, using the Association of Official Agricultural Chemists (A.O.A.C., 1997) procedures. Lindsay and Norvell, (1978) procedure was used for determination of Ca, Mgt, S, Zn, Cu, Mn and boron.

## RESULTS AND DISCUSSION

### Mineral contents in dry leaves

The data presented in Table 1 indicted that the application of 75% RDF along with VAM fungi and $GA_3$ upto 20 ppm ($T_{15}$) recorded significantly higher mineral contents in dry leaves of Moringa. Amongst the major nutrients, N, P and K contents in dry leaves were 3.14, 70.31 and 244.34 mg/100g, respectively. In case of secondary nutrients, S, Ca and Mg contents were 417.01, 45.345 and 40.71 mg/100g, respectively. Similarly in case of micronutrients, Zn, Cu, Mn and boron in dry leaves were 42.92, 0.97 and 0.25 mg/100g, respectively. The second, third and fourth best treatments were $T_{14}$, $T_{13}$ and $T_{12}$, respectively having the same RDF and $GA_3$ levels but different biofertilizers.

### Nutrient contents in pods and seeds

The data highlighted Table 2 revealed that the major, secondary and micro-nutrient contents in dry leaves, pods and seeds of drumstick were significantly influenced due to applied treatments. All the applied treatments ($T_1$ to $T_{15}$) proved significantly superior in augmenting all these nutrients as compared to the control ($T_0$). Amongst the treatments, $T_{15}$ having 75 % RDF + VAM fungi + 20 ppm $GA_3$ proved significantly superior to rest of the treatments where pods were 3.81, 11.08 and 258.23 mg / 100 g, respectively. Similarly S, Ca and Mg contents were 128.93, 39.81 and 4.06 mg /100 g, respectively. In case of micronutrients, Zn, Cu, Mn and B were 45.34, 3.76, 24.77 and 0.092 mg/100 g, respectively.

The same treatment ($T_{15}$) also recorded all these nutrient contents upto maximum extent in seeds also. Accordingly, N, P and K contents in seeds were 3.78, 53.24, 381.65 mg/100 g, respectively. In case of secondary nutrients, S, Ca and Mg contents were 0.069, 4.64 and 63.78 mg/100 g, respectively. Amongst the micronutrients, Zn, Cu, Mn and B contents were 5.89, 5.83, 30.34 and 0.075 mg/100 g, respectively.

The second third and fourth best treatments were $T_{14}$, $T_{13}$ and $T_{12}$ having included, PSB, PMB and *Azotobacter*, respectively along with 20 ppm $GA_3$.

It is quite apparent that amongst the biofertilizers, VAM fungi performed the best in comparison to PSB (phosphate solubilizing bacteria). Similarly PSB proved better than PMB (phosphate-mobilizing mycorrhiza fungi) under the same level of 75 % RDF and 20 ppm $GA_3$. *Azotobacter* exhibited the lowest performance. Thus the application of VAM fungi, PSB and PMB might have increased the continuous availability of phosphorus to the soil microbial activities, root and shoot growth of plants. Profuse root development particularly due to increased availability of phosphorus to trees insured more absorption of minerals, nutrients and soil moisture from the deeper soil layers.

The combined application of NPK fertilizers, biofertilizers and growth regulator $GA_3$ by virtue of their different nature have performed different well-known functions in the soil and played unique role for the easy availability of multi-nutrients to the actively growing plants, ultimately the combined benefits of all these applied inputs must have availed by the drumstick trees which resulted in sufficient uptake and utilization of nutrients with their increased translocation to the reproductive parts (pods and seeds). These results are in consonance with those of Rafeekher *et al.* (2002), Pathak *et al.* (2003), Singh *et al*. (2004), Patel *et al*. (2005), Sharma *et al*. (2006), and Dubey*et al*. (2010), Singh *et al*. (2016) and Hedden (2020).

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**Table 1 Mineral nutrient contents (mg/ 100 g) in dried Moringa leaves as influenced by biofertilizers and $GA_3$**

| Treatments | N-content in dry leaves (mg/100g) | P-content in dry leaves (mg/100g) | K-content in dry leaves (mg/100g) | S-content in dry leaves (mg/100g) | Ca-content in dry leaves (mg/100g) | Mg-content in dry leaves (mg/100g) | Zn-content in dry leaves(mg/100g) | Cu-content in dry leaves (mg/100g) | Mn-content in dry leaves(mg/100g) | Boron content in dry leaves mg/100g) |
|---|---|---|---|---|---|---|---|---|---|---|
| $T_0$ | 2.04 | 42.19 | 150.59 | 197.87 | 21.22 | 18.21 | 21.66 | 0.36 | 0.49 | 0.15 |
| $T_1$ | 2.19 | 61.50 | 218.60 | 388.49 | 32.25 | 27.83 | 32.69 | 0.57 | 0.81 | 0.21 |
| $T_2$ | 2.23 | 66.96 | 241.13 | 392.64 | 33.64 | 30.68 | 34.36 | 0.59 | 0.83 | 0.21 |
| $T_3$ | 2.35 | 65.94 | 241.20 | 394.36 | 33.91 | 32.38 | 39.78 | 0.61 | 0.84 | 0.21 |
| $T_4$ | 2.52 | 66.82 | 241.24 | 396.24 | 35.34 | 33.74 | 39.90 | 0.48 | 0.84 | 0.21 |
| $T_5$ | 2.60 | 67.03 | 241.29 | 397.71 | 36.22 | 34.47 | 40.00 | 0.61 | 0.84 | 0.22 |
| $T_6$ | 2.66 | 67.20 | 241.36 | 398.56 | 36.77 | 35.30 | 40.22 | 0.55 | 0.85 | 0.22 |
| $T_7$ | 2.75 | 67.21 | 241.53 | 399.78 | 37.25 | 35.58 | 40.66 | 0.58 | 0.84 | 0.22 |
| $T_8$ | 2.80 | 67.47 | 241.72 | 401.23 | 38.17 | 35.85 | 40.83 | 0.65 | 0.85 | 0.22 |
| $T_9$ | 2.86 | 68.32 | 242.12 | 402.30 | 39.33 | 36.18 | 40.94 | 0.71 | 0.87 | 0.23 |
| $T_{10}$ | 2.94 | 68.49 | 242.18 | 404.32 | 41.32 | 36.43 | 41.03 | 0.74 | 0.93 | 0.23 |
| $T_{11}$ | 2.93 | 68.67 | 242.30 | 408.37 | 41.91 | 36.81 | 41.06 | 0.81 | 0.93 | 0.23 |
| $T_{12}$ | 3.01 | 68.84 | 242.44 | 410.30 | 43.13 | 37.25 | 41.17 | 0.86 | 0.95 | 0.24 |
| $T_{13}$ | 3.05 | 69.06 | 243.14 | 412.18 | 43.96 | 37.57 | 41.94 | 0.95 | 0.95 | 0.24 |
| $T_{14}$ | 3.06 | 69.80 | 243.41 | 414.37 | 44.50 | 37.98 | 42.12 | 0.96 | 0.96 | 0.24 |
| $T_{15}$ | 3.14 | 70.31 | 244.34 | 417.01 | 45.45 | 40.71 | 42.92 | 0.97 | 0.97 | 0.25 |
| **S.Em±** | **0.008** | **0.14** | **0.20** | **0.18** | **0.046** | **0.038** | **0.130** | **0.009** | **0.008** | **0.05** |
| **C.D. (P=0.05)** | **0.024** | **0.39** | **0.59** | **0.51** | **0.13** | **0.109** | **0.38** | **0.26** | **0.023** | **0.013** |

Table 2 Mineral nutrient contents (mg/ 100 g) in pods of drumstick as influenced by biofertilizers and $GA_3$

| | Major nutrients | | | Secondary nutrients | | | Micronutrients | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | N-content (mg/ 100 g) | P-content | K-content | S-content | Ca-content | Mg-content | Zn-content | Cu-content | Mn-content | B-content |
| $T_0$ | 1.95 | 7.07 | 216.47 | 110.26 | 23.37 | 2.69 | 34.35 | 1.98 | 19.99 | 0.033 |
| $T_1$ | 3.29 | 10.86 | 256.85 | 126.37 | 38.05 | 3.26 | 43.37 | 3.16 | 24.27 | 0.074 |
| $T_2$ | 3.29 | 10.87 | 257.14 | 126.90 | 38.21 | 3.36 | 43.41 | 3.20 | 24.28 | 0.074 |
| $T_3$ | 3.30 | 10.87 | 257.51 | 127.05 | 38.06 | 3.56 | 43.36 | 3.23 | 24.32 | 0.075 |
| $T_4$ | 3.33 | 10.87 | 257.51 | 127.03 | 37.97 | 3.66 | 43.27 | 3.27 | 24.34 | 0.079 |
| $T_5$ | 3.33 | 10.88 | 257.52 | 127.07 | 38.21 | 3.59 | 43.31 | 3.30 | 24.39 | 0.078 |
| $T_6$ | 3.36 | 10.88 | 257.52 | 127.13 | 38.31 | 3.67 | 43.51 | 3.35 | 24.40 | 0.081 |
| $T_7$ | 3.38 | 10.88 | 257.53 | 127.18 | 38.33 | 3.69 | 43.54 | 3.38 | 24.43 | 0.083 |
| $T_8$ | 3.41 | 10.88 | 257.56 | 127.27 | 38.38 | 3.63 | 43.59 | 3.43 | 24.44 | 0.086 |
| $T_9$ | 3.43 | 10.89 | 257.57 | 127.36 | 38.48 | 3.70 | 43.63 | 3.46 | 24.47 | 0.087 |
| $T_{10}$ | 3.46 | 10.86 | 257.59 | 127.49 | 38.56 | 3.82 | 43.64 | 3.50 | 24.50 | 0.088 |
| $T_{11}$ | 3.48 | 10.89 | 257.62 | 127.56 | 38.66 | 3.83 | 43.75 | 3.54 | 24.52 | 0.090 |
| $T_{12}$ | 3.51 | 10.90 | 257.75 | 127.61 | 37.41 | 3.88 | 43.81 | 3.54 | 24.57 | 0.090 |
| $T_{13}$ | 3.54 | 10.91 | 257.93 | 127.93 | 38.80 | 3.92 | 43.85 | 3.62 | 24.62 | 0.093 |
| $T_{14}$ | 3.60 | 10.96 | 258.01 | 128.13 | 38.98 | 3.98 | 43.92 | 3.66 | 24.70 | 0.094 |
| $T_{15}$ | 3.81 | 11.08 | 258.23 | 128.93 | 39.81 | 4.06 | 45.34 | 3.76 | 24.77 | 0.092 |
| **S.Em$\pm$** | **0.02** | **0.21** | **0.11** | **0.07** | **0.34** | **0.13** | **0.37** | **0.01** | **0.04** | **0.001** |
| **C.D. (P=0.05)** | **0.06** | **0.62** | **0.31** | **0.21** | **1.00** | **0.38** | **1.08** | **0.03** | **0.13** | **0.003** |

**Table 3 Mineral nutrient contents (mg/ 100 g) in seeds of drumstick as influenced by biofertilizers and $GA_3$**

| | Major nutrients (mg/ 100 g) | | | Secondary nutrients (mg/ 100 g) | | | Micronutrients (mg/ 100 g) | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Treatments | N-content | P-content | K-content | S-content | Ca-content | Mg-content | Zn-content | Cu-content | Mn-content | B-content |
| $T_0$ | 3.07 | 41.21 | 341.14 | 0.055 | 2.76 | 50.52 | 4.63 | 3.29 | 13.95 | 0.023 |
| $T_1$ | 3.39 | 52.53 | 380.34 | 0.050 | 4.56 | 63.68 | 5.64 | 5.43 | 28.73 | 0.035 |
| $T_2$ | 3.38 | 52.55 | 380.55 | 0.060 | 4.55 | 63.68 | 5.66 | 5.47 | 28.74 | 0.038 |
| $T_3$ | 3.40 | 52.54 | 380.61 | 0.062 | 4.55 | 63.68 | 5.65 | 5.49 | 28.46 | 0.042 |
| $T_4$ | 3.41 | 52.73 | 380.64 | 0.062 | 4.57 | 63.69 | 5.65 | 5.51 | 28.85 | 0.045 |
| $T_5$ | 3.52 | 52.59 | 380.69 | 0.062 | 4.57 | 63.69 | 5.65 | 5.54 | 28.88 | 0.048 |
| $T_6$ | 3.54 | 52.62 | 380.75 | 0.062 | 4.58 | 63.70 | 5.67 | 5.54 | 28.91 | 0.049 |
| $T_7$ | 3.49 | 52.65 | 380.82 | 0.063 | 4.58 | 63.70 | 5.67 | 5.55 | 28.97 | 0.052 |
| $T_8$ | 3.51 | 54.33 | 380.87 | 0.063 | 4.58 | 63.75 | 5.65 | 5.56 | 29.00 | 0.055 |
| $T_9$ | 3.55 | 52.68 | 380.93 | 0.065 | 4.59 | 63.70 | 5.68 | 5.56 | 29.03 | 0.057 |
| $T_{10}$ | 3.61 | 52.72 | 380.98 | 0.064 | 4.59 | 63.71 | 5.68 | 5.58 | 29.09 | 0.060 |
| $T_{11}$ | 3.62 | 53.07 | 381.03 | 0.064 | 4.60 | 63.72 | 5.69 | 5.63 | 29.13 | 0.063 |
| $T_{12}$ | 3.67 | 52.77 | 381.10 | 0.064 | 4.60 | 63.72 | 5.69 | 5.67 | 29.18 | 0.065 |
| $T_{13}$ | 3.71 | 52.81 | 381.17 | 0.065 | 4.60 | 63.72 | 5.70 | 5.68 | 29.21 | 0.070 |
| $T_{14}$ | 3.74 | 52.87 | 381.25 | 0.065 | 4.61 | 63.73 | 5.73 | 5.70 | 29.53 | 0.073 |
| $T_{15}$ | 3.78 | 53.24 | 381.65 | 0.069 | 4.64 | 63.78 | 5.89 | 5.83 | 30.34 | 0.075 |
| **S.Em±** | **0.03** | **0.43** | **0.09** | **0.002** | **0.01** | **0.08** | **0.01** | **0.02** | **0.22** | **0.000** |
| **C.D. (P=0.05)** | **0.09** | **1.25** | **0.27** | **0.005** | **0.03** | **0.23** | **0.02** | **0.07** | **0.64** | **0.001** |