Journal of Advanced Zoology
ISSN: 0253-7214
Volume 45 Issue 1 Year 2024 Page 818-824

Green Synthesis Of Composite NPK Fertilizer For Sustainable Agriculture

B.R. Saikishore Kumar[1], Jagadeesh Kumar Ega[2*], Suma Sanikommu[3*]

[1]*Research Scholar, Department of Biochemistry Chaitanya Deemed to be University, Hanmakonda, Warangal Urban-506001, Telanagana, INDIA. Email: kishorechemistry.87@gmail.com,*
[2*]*Prof Department of Chemistry, Department of Biochemistry Chaitanya Deemed to be University, Hanmakonda, Warangal Urban-506001, Telanagana, INDIA. Email: jkjagadeeshkumare@gmail.com*
[3*]*Prof, Department of Biochemistry Chaitanya Deemed to be University, Hanmakonda, Warangal Urban-506001, Telanagana, INDIA.*

***Corresponding Author:** Jagadeesh Kumar Ega, Suma Sanikommu*
**Prof Department of Chemistry, Department of Biochemistry Chaitanya Deemed to be University, Hanmakonda, Warangal Urban-506001, Telanagana, INDIA. Email: jkjagadeeshkumare@gmail.com*
**Prof, Department of Biochemistry Chaitanya Deemed to be University, Hanmakonda, Warangal Urban-506001, Telanagana, INDIA.*

Article History

Received:
Revised:
Accepted

Abstract

The one step combination of an objective particle in a similar response vessel is generally viewed as an effective methodology in manufactured natural science. Several one step synthesis of biologically active molecules, primarily employing organo catalytic methods, is discussed in this overview, along with their strengths and weaknesses. The one step economy ideas presented here are not only applicable to catalysis but also to organometallic and organic reaction techniques in general. A synthesis that requires multiple steps could instead be carried out in a single reaction flask with a one step synthesis. Envision that a union including numerous means expects that you stir up the response at each step, then decontaminate and carry on the material to the following stage. During workup and/or purification, you will, of course, lose some materials regardless of how cautiously you move chemicals from flask to flask. As a result, I believe that the fact that it is less likely to lose material during workup and purification is the most significant advantage. The use of chemicals and solvents is cost-effective, which is the second benefit. If the reaction needs to be worked up at each step, you will almost always need to use solvents that will eventually go to waste. Multiple-step one-flask synthesis would only require final workup at the final step.

Keywords:* *Synthesis, Envision, regardless, strengths and weaknesses.

Introduction

An experiment was carried out in 2010–11 to determine the "Response of foliar feeding of Gluconate and EDTA chelated plant nutrients on growth, yield, and absorption of nutrients by leaves in Bt-cotton under rainfed condition." There are seventeen treatment options in the experiment, namely, T_1: Zn gluconate; T_2: Mn gluconate; T_3: Cu gluconate; T_4: Fe gluconate; T_5: Ca gluconate; T_6: Mg gluconate; T_7: combination of all gluconate; T_8: Zn-EDTA; T_9: Mn EDTA; T_{10}: Cu EDTA; T_{11}: Fe EDTA; T_{12}: Ca EDTA; T_{13}: grade II, T_{16}-Water splash and T_{17}-Control imitated two times. P_2O_5, 120:60:60 N and K_2O Kg ha^{-1} were used to fertilize the treatments. At 75 Days, nutrients chelated with EDTA and gluconate were sprayed onto the leaves. At 80, 100, and 120 Days, biometric measurements such as the plant's height, number of leaves, and leaf area, as well as yield characteristics such as the number of bolls per plant, their weight, and yield, were taken. Utilizing an appropriate method, the nutrient concentration was determined immediately after 3, 6, 12, 24, 36, and 48 hours of spraying (1). To determine the duration of plant nutrient absorption, five leaves from each treated plant were collected. The conclusion was that Zn gluconate feeding in the leaves led to the greatest growth and yield. Zn gluconate-foliar feeding had the greatest absorption time, which was between three and six hours (2). After six hours, the application of Fe Gluconate, followed by Fe EDTA, led to a higher iron concentration than the control. While Bt absorbed the most manganese when manganese gluconate was applied, Plant for cotton. After six hours of spraying, Cu Gluconate was found to have a greater absorption rate than control, water spray, and Government grade.

Gosspium spp. cotton is one of the most important commercial crops, influencing the world's economic, political, and social status. As a result, it has remained known as the "King of Fibers" and "White Gold" because it has a higher economic value than other cultivable crops. The superiority of Indian cotton fabrics, which were referred to as the "Web of woven mind," prompted European nations to seek new trade routes with India. The cotton industry, which is one of India's major industries and contributes 12% to the export basket with improved cotton productivity and other innovations, continued to provide significant support to the Indian economy. In the creation line, India will be in a situation to get more unfamiliar trade and procured Rs. 10270.21 crores from commodity of 83.00 lakh parcels in 2009-10 (Cotton Warning Board). The supplement supply is the second most significant restricting component in cotton creation solely after water. In most cases, the soils in the rainfed area are not only hungry for the nutrients but also thirsty. Deficits in soil's macro and micronutrients are essentially what cause nutritional stress in soils. In a balanced plant diet, deficiency, disorder, and demand are all linked internally. One of the main factors that reduce crop yields is a lack of macronutrients in the soil. The excessive removal of essential nutrients from the soil reserves, which eventually led to the deficiency of micronutrients in soils, has been caused by continuous cropping of high yielding varieties without the proper substitution of inorganic fertilizers, the absence of micronutrients, and the application of organic manures at all (3). There is an earnest need to focus on the issue accurately mid explicitly for exact manure solution. Thus, for huge improvement underway and efficiency of cotton, these imperatives, as a matter of fact should be dealt with first concern in the examination plan. Utilizing an integrated approach to the efficient management of nutrients, cotton productivity in other wards can be significantly enhanced. The nutritional requirement of Bt cotton could be maintained by applying the deficient nutrient through soil application and foliar spray, taking into account the capacity and benefits of Bt cotton in terms of yield and quality.

A lack of knowledge about how much, what kind, and how to apply fertilizer to a field for a particular crop also leads to either too little or too much fertilizer being applied, which causes nutrients to be out of balance. Using fertilizer with a balance of nutrients is necessary to keep a high yield. The soil, where plant roots are designed to absorb water and nutrients, has traditionally been regarded as the most obvious source of plant nutrition. However, in recent years, foliar feeding has been developed to meet the nutritional requirements of plants. The practice of feeding a plant via its leaves rather than its roots with a liquid plant nutrient or nutrient additive is known as "foliar feeding." It is a method of fertilizing plants that involves spreading a solution of fertilizer directly onto the leaves. The tiny pores in the leaves allow the fertilizer to enter the plant and provide the nutrients it needs. The goal of fertilization is to first increase the rate of photosynthesis in the leaves, which then stimulates nutrient absorption by plant roots. Foliar nutrients are mobilized directly into plant leaves. The plant metabolism accelerates when the foliar plant food is sprayed onto the leaves. The plant becomes more dependent on the root system for water and nutrients as a result. The potential for increased yield comes from this rise in the amount of nutrients and water delivered by the roots. It is a quick and efficient method of supplying the micronutrients and is one of the ways to replenish the necessary nutrient during crucial growth stages. EDTA (Ethylendiamine Tetra Acetic Acid), which has the ability to form stable soluble complexes with certain monovalent, divalent, and trivalent metal ions, could be used to provide these micronutrients. Chelates, in which multiple chemical bonds firmly bind chemical compounds to a molecule, are used. Chelation is the process of forming a ring structure by binding a specific organic molecule, known as a "ligand," to a mineral ion at two or more locations. Chelates can be either natural or synthetic. Thus, the foliar application expects more prominent significance, as the supplements are gotten the quick area of the using region for example foliage.

Materials and Methods

During the kharif season of 2010–11, the Department of Soil Science and Agril carried out a potted experiment. Parbhani, MKV, and chemistry. For the purpose of the experiment, 12-kg-capacity large cement pots were used. Paint was used to mark the symbols for the treatment. A two-millimeter nylon screen was used to filter the clean, air-dried soil. Twenty pots were used in the pot culture experiment to investigate the foliar feeding method of Gluconate and EDTA chelated micronutrient absorption. Foliar sprays of Zn, Mn, Cu, Fe, Ca, Mg Gluconate, all Gluconate, through Zn, Mn, Cu, Fe, Ca, Mg EDTA, all EDTA, straight fertilizer spray, water spray, and control were among the treatments. The seed was sown on July 2 of this year. Each pot contained two seeds of the RCH-2 (BG-II) variety, which were watered as necessary on a regular basis. Urea, single super phosphate, and muriate of potash were used to fertilize the pots at a ratio of 120:60:60 kg NPK ha-1, respectively (4,5). At 75 Days, a Gluconate and EDTA-chelated foliar spray was administered. Biometric analysis, for example, At 80, 100, and 120 Days, the plant's height, number of leaves, leaf area, number of bolls, weight of each boll, and yield were measured. Observations were made 3, 6, 12, 24, 36, and 48 hours after the nutrient spray. The absorption of plant nutrients by the various treatments was determined by collecting five leaves from each pot that had been treated. Due to the combination of replication and treatments, the field experiment's data were subjected to an analysis of variance, and the degree of freedom was divided into various variances (6). For the purpose of determining the "F" value and, ultimately, testing the significance, these were contrasted with error variance. When the results were found to be significant, the critical difference (CD) was calculated for comparing the treatment means at a 5% level of significance. The standard error (SE) for the treatment was calculated using error variance (7). According to Panse and Sukhatme's statistical method for agricultural workers (1987), the results were statistically analyzed.

Results and Discussion

Plant height was measured at 100 and 120 Days following application of the chelated nutrients spray (8). Bt cotton crop heights ranged from 24.23 to 57.41 and 31.52 to 65.55 cm, respectively, at 100 and 120 Days. The successful treatment for expanding the level of the Bt cotton crop was zinc Gluconate (T_4) for example 57.41 and 65.55 cm, individually. Same medicines like T_5 (Zn EDTA), T_{10} (Fe Gluconate) and T_{11} (Fe EDTA) firmly followed the treatment T_4 (Zn Gluconate).

Number of leaves

According to Table 1, the highest numbers of leaves were recorded with treatment T4, which consisted of spraying zinc Gluconate at 100 and 120 Days, respectively. In contrast, in treatment T_1 (the control), the lowest values were 43.50, 59.25, and 66.50 leaves, respectively.

Leaf area

The application of zinc Gluconate resulted in the greatest amount of leaf area (2562 and 3093 cm^2). At 100 and 120 Days, however, treatment T_1 (the control) had the lowest leaf area (1136.09 and 1401.72 cm^2), respectively. The findings are consistent with what Sarkar and Aery (1990) said when they said that BT cotton crop leaf area increased after Zn was applied to a pot trial (9).

Dry weight

The dry weight of the BT cotton crop after harvest was recorded, as shown in Table 2. According to these records, the dry weight was 61.69 g plant-1 in the control and 104.74 g plant-1 in the Zn Gluconate spray. The dry matter of BT cotton plants significantly increased in response to the treatment T4 (Zn Gluconate).

Yield parameters

After 80 Days, the following yield parameters were influenced by a single foliar application of Gluconate and EDTA-chelated plant nutrient:

Yield

The application of zinc Gluconate significantly increased the number of bolls in the plant1 Compared to the lowest treatment T_1 (control), which had 11 bolls plant-1, the highest number—39 bolls plant-1—was observed. The foliar application of T_4 (zinc Gluconate) (3.43 g) to the Bt cotton crop resulted in the heavier weight of the bolls, which ranged from 2.08 to 3.43 g. The yield per plant was highest when zinc Gluconate (133.77 g) was applied, followed by T10 (Fe Gluconate) (116.64 g) and T_5 (Zn EDTA) (115.6 g). The lowest yield was observed in treatment T_1 (the control).

Effect of foliar feeding of Gluconate and EDTA chelated plant nutrient on concentration of plant nutrients in leaves.

After 3, 6, 12, 24, 36, and 48 hours, observations were made immediately following the spray. Tables 1 to 8 contain information about the various nutrients (10).

Ca concentration

The treatment T_4 (Ca gluconate) has been observed to have an increasing trend in the Ca concentration of Bt cotton plants over time. The rate of absorption also Ca absorption was particularly rapid here, peaking between 3 and 6 hours and slowing down until 48 hours. T_4 (Ca gluconate) had the highest Ca absorption of any of the treatments, followed by T_5 (Ca EDTA), and T_1 (control) had the lowest absorption.

Mg concentration

The Bt cotton plants had the highest concentration of magnesium when Mg Gluconate (T_4) was applied. Maximum absorption was clearly observed between the ages of three and six hours. T_4 (Mg Gluconate) was the next treatment, closely followed by T_5 (Mg EDTA). Between six and twelve hours, absorption was at its peak. The T_3 (Government grade 2) was found to play the same absorption role.

Zn concentration

Compared to T_1 (control) and T_2 (water spray), foliar feeding of zinc Gluconate (T_4) had a greater effect on zinc absorption by BT cotton. Zinc absorption did not significantly alter between the T_1 and T_2 treatments. While the amount and rate of zinc absorption were highest during the 3-6 hours in Gluconate complexed Zn salt, followed by T_5 (Zn EDTA), absorption by treatment T_3 (Government grade 2) was superior between 6 and 12 hours. Das and others, 2004) stated that the application of Zn in the form of Zn EDTA has consistently outperformed Zn application in terms of soil and plant Zn content, resulting in a greater yield increase. Jat and Mehra (2007) expressed that the positive impact of zinc on photosynthesis and metabolic cycles increases the development of photosynthesis and their movement to various plant parts including grain.

Fe concentration

The average mean iron concentrations, which ranged from 30.60 to 34.91 mg kg-1, are shown. The iron concentration average mean ranged from 30.60 to 34.91 mg kg-1 are presented. The rate and maximum absorption were observed with the treatment T_4 (Fe Gluconate), which was followed numerically by T_5 (Fe EDTA). According to Gangadhar et al., the rate and maximum absorption were observed with the treatment T_4 (Fe Gluconate) (from 36.24 to 43.79), which was numerically closed by the treatment T_5 (Fe EDTA). 1992) reported that the application of $FeSO_4$ significantly increased the crop's uptake of nutrients and the amount of Fe, Zn, Mn, Cu, and B nutrients in the index leaf (the fourth leaf).

Mn concentration

The results in Table 7 showed that applying the same nutrient to the leaves helped the plants absorb it better. Here likewise T_4 (Mn Gluconate) splash helped for assimilation of manganese by Bt cotton plants than any remaining medicines.

TABLE 1, 2. Effects of foliar feeding Bt cotton in a pot culture experiment with Gluconate and EDTA chelated plant nutrients on fresh weight, dry weight, number of bolls, weight of bolls, and weight of bolls g plant-1

Height of plant (cm)		Number of leaves		Leaf area (cm2)		**Treatment**	Dry weight (g palnt-1)	Number of bolls plant-1	Weight of boll (g)	Yield (g plant-1)
100 DAS	120 DAS	100 DAS	120 DAS	100 DAS	120 DAS					
24.23	31.52	59.25	66.50	1136.09	1401.72	**T_1-Control**	61.69	11	2.08	22.88
29.01	37.40	64.75	73.25	1308.27	1620.44	**T_2-Water spray**	65.39	15	2.30	34.50
39.28	51.37	76.25	90.25	1810.09	2250.13	**T_3-Government grade 2**	80.02	23	2.96	68.08
57.41	65.55	105.50	121.00	2562.82	3093.06	**T_4-Zn Gluconate**	104.74	39	3.43	68.08

56.78	64.79	103.00	119.75	2501.85	3001.75	**T_5-Zn EDTA**	102.97	34	3.40	115.60
43.75	53.10	84.75	101.25	1957.69	2498.55	**T_6-Mn Gluconate**	186.25	27	3.06	82.62
42.21	53.00	83.50	97.50	1923.47	2418.24	**T_7-Mn EDTA**	85.73	26	3.03	78.78
38.36	46.25	75.50	86.00	1663.45	2132.73	**T_8-Cu Gluconate**	78.34	23	2.90	66.70
37.15	45.76	74.00	84.75	1559.01	2109.12	**T_9-Cu EDTA**	76.85	20	2.82	56.40
52.98	61.80	99.50	115.25	2373.18	2849.71	**T_{10}-Fe Gluconate**	99.15	36	3.24	116.64
52.08	61.59	97.50	112.50	2298.75	2782.90	**T_{11}-Fe EDTA**	99.01	30	3.21	96.30
33.87	42.09	70.50	80.00	1500.67	2099.65	**T_{12}-Ca EDTA**	69.11	18	2.69	48.42
33.69	41.88	68.75	78.75	1478.82	1901.14	**T_{13}- Mg Gluconate**	68.39	16	2.63	42.08
48.72	57.77	92.50	108.50	2087.64	2615.21	**T_{14}- Mg EDTA**	95.61	31	3.12	96.72
48.19	57.63	90.25	105.00	2009.50	2673.64	**T_{15}- Mg EDTA**	94.82	30	3.10	93.00
42.51	51.43	83.03	96.01	1878.08	2363.19	**Mean**	90.10	25.26	2.93	76.83

Cu concentration

The Bt cotton plants had the highest concentration of copper when Cu Gluconate (T_4) was applied. Maximum absorption was formed between the ages of three and six hours. T_4 (Cu Gluconate) was the next treatment, closely followed by T_5 (Cu EDTA). Between 6 and 48 hours, absorption was at its peak. The T_3 (Government grade 2) was found to play the same absorption role.

Table 3. The effect on the Ca concentration of Bt cotton in a pot culture experiment of foliar feeding of Gluconate and EDTA-chelated plant nutrients.

Treatment	**Ca concentration**					
	3 hrs.	**6 hrs.**	**12 hrs.**	**24 hrs.**	**36 hrs.**	**48 hrs.**
T_1-Control	0.32	0.32	0.32	0.32	0.33	0.33
T_2-Water spray	0.33	0.30	0.34	0.38	0.38	0.38
T_3-Governemnt grade 2	0.43	0.43	0.48	0.49	0.51	0.53
T_4-CaGluconate	0.69	0.78	0.79	0.81	0.83	0.85
T_5- Ca EDTA	0.60	0.65	0.66	0.67	0.69	0.71
Mean	**0.47**	**0.50**	**0.52**	**0.53**	**0.55**	**0.56**

Table. 4 Effect of foliar of Gluconate EDTA Chelated plant nutrient on Mg Concentration of BT cotton in pot culture experiment

Treatment	**Mg concentration**					
	3 hrs.	**6 hrs.**	**12 hrs.**	**24 hrs.**	**36 hrs.**	**48 hrs.**
T_1-Control	0.26	0.26	0.27	0.27	0.27	0.28
T_2-Water spray	0.28	0.28	0.30	0.31	0.31	0.32
T_3-Governemnt grade 2	0.33	0.33	0.37	0.38	0.39	0.41
T_4-Mg Gluconate	0.45	0.53	0.55	0.56	0.58	0.59
T_5-Mg EDTA	0.42	0.49	0.50	0.51	0.52	0.53
Mean	**0.35**	**0.38**	**0.40**	**0.41**	**0.41**	**0.43**

TABLE.5 Effect Of Foliar Feeding Of Gluconate And EDTA Chelated Plant Nutrient On ZN Concentration Of BT Cotton In Pot Culture Experiment.

Treatment	**Zn concentration**					
	3 hrs.	**6 hrs.**	**12 hrs.**	**24 hrs.**	**36 hrs.**	**48 hrs.**
T_1-Control	17.52	17.52	17.53	17.53	17.55	17.55
T_2-Water spray	20.84	20.84	20.35	20.37	21.17	21.20
T_3-Governemnt grade 2	24.11	24.22	26.74	26.78	26.80	27.90
T_4-Zn Gluconate	8.63	36.15	37.23	39.09	40.35	40.44
T_5-Zn EDTA	28.04	35.42	35.79	36.18	36.29	36.65
Mean	**23.83**	**26.73**	**27.53**	**27.99**	**28.43**	**28.75**

Table.6 Effect of foliar feeding of Gluconate and EDTA chelated plant nutrient on Fe concentration of BT cotton in pot culture experiment

Treatment	**Fe concentration**					
	3 hrs.	**6 hrs.**	**12 hrs.**	**24 hrs.**	**36 hrs.**	**48 hrs.**
T_1-Control	23.43	23.44	23.46	23.46	23.47	23.50
T_2-Water spray	27.01	27.06	27.50	27.50	27.77	28.01
T_3-Governemnt grade 2	30.56	31.85	36.04	37.18	38.92	39.12
T_4 -Fe Gluconate	36.24	40.78	41.04	41.98	42.35	43.79
T_5-Fe EDTA	35.77	36.23	36.41	39.06	39.88	40.15
Mean	**30.60**	**31.87**	**32.89**	**33.84**	**34.48**	**34.91**

Table.7 Effect of foliar feeding of Gluconate and EDTA chelated plant nutrient on Mn concentration of BT cotton in pot culture experiment.

Treatment	**Mn concentration**					
	3 hrs.	**6 hrs.**	**12 hrs.**	**24 hrs.**	**36 hrs.**	**48 hrs.**
T_1-Control	1.99	1.99	1.99	2.00	2.00	2.01
T_2-Water spray	2.16	2.16	2.17	2.18	2.18	2.21
T_3-Governemnt grade 2	3.56	3.62	4.18	4.20	4.21	4.21
T_4 –Mn Gluconate	4.19	4.23	4.24	4.25	4.25	4.27
T_5- Mn EDTA	4.10	4.18	4.21	4.21	4.22	4.23
Mean	3.20	3.24	3.36	3.37	3.37	3.39

Table.8 Effect of foliar feeding of Gluconate and EDTA chelated plant nutrient on Cu concentration of BT cotton in pot culture experiment.

Treatment	**Cu concentration**					
	3 hrs.	**6 hrs.**	**12 hrs.**	**24 hrs.**	**36 hrs.**	**48 hrs.**
T_1-Control	2.56	2.56	2.56	2.57	2.57	2.58
T_2-Water spray	2.75	2.75	2.76	2.77	2.77	2.77
T_3-Governemnt grade 2	3.05	3.08	3.15	3.16	3.16	3.18
T_4 -Cu Gluconate	3.79	3.85	3.86	3.88	3.87	3.90
T_5- Cu EDTA	3.79	3.80	3.80	3.80	3.82	3.83
Mean	**3.19**	**3.21**	**3.23**	**3.24**	**3.24**	**3.25**

T4 (Mn Gluconate) was between 4.19 and 4.27, T_5 (Mn EDTA) was between 4.10 and 4.23, and T_3 (Government grade 2) was between 3.56 and 4.21. In treatment T_4 (Mn Gluconate) and T_5 (Mn EDTA), Mn absorption was greatest between 3 and 6 hours, while in treatment T_3 (Government grade 2), it was greatest between 6 and 12 hours. The treatments with the lowest concentrations were T_1 (1.99 to 2.01) and T_2 (2.16-2.21 mg kg-1) (control and water spray, respectively). Cu concentration it was evident from Table 8 that both the T_1 and T_2 treatments had very low copper absorption. The most extreme copper fixation was tracked down in treatment T_4 (Cu Gluconate) (3.79 to 3.90) trailed by T5 (Cu EDTA) (3.79 to 3.83). According to the data, treatment T_4 (Cu Gluconate) had the highest copper concentration and maximum absorption three to six hours after spraying.

Conclusion:

Utilizing Zn Gluconate resulted in the greatest absorption, which occurred between three and six hours after administration. When compared to the control (T_1), the application of manganese Gluconate resulted in the highest manganese absorption by Bt cotton plants, while the application of Fe Gluconate resulted in a higher iron concentration six hours later (T_4), followed by Fe EDTA (T_5). After six hours of application, Cu Gluconate was absorbed at a higher rate, resulting in a higher concentration than the control, water spray, or Government grade. In the pot culture experiment, it was determined that Zn Gluconate foliar feeding improved yield parameters like the number and weight of bolls as well as plant height, leaf area, and dry weight per plant-1 over all treatments. Within three to six hours of spraying, the foliar feeding of Ca, Mg, Zn, Fe, Mn, and Cu with Gluconate was found to be effective in ensuring that the corresponding nutrients were absorbed.

References

1. Anonymous, (2010). Cotton advisory board, Cotton Corporation of India 2010.
2. Das, D.K., Karak, T., and D. Maiti (2004). Effect of foliar application of different sources of Zn on the changes in Zn content, uptake and yield of rice
3. Gangadhar, G.A., H.M. Manjunathaiah and T. Satyanarayana (1992). Effect of micronutrients on the yield and uptake of sunflower.
4. Jat, J.R. and R.K. Mehra (2007). Effect of sulphur and zinc on yield, micronutrient content in and uptake by mustard on haplustepts.
5. Sarkar, S. and N.C. Aery (1990). Effect of zinc on growth of soybean. Indian
6. Panse, V.G. and P.V. Sukhatme (1988). Statistical methods of Agricultural Workers, ICAR Publication, New Delhi.
7. Mortvedt, JJ; Beaton, JD. "Heavy Metal and Radionuclide Contaminants in Phosphate Fertilizers"
8. Kesler and Simon, Stephen and Simon (2015). Mineral Resources, Economics and the Environment.
9. G. J. Leigh (2004). The world's greatest fix: a history of nitrogen and agriculture
10. Chambers, Albert; Sally Rutherford (27 November 2007). "Voluntary Standards for the Fertilizer and Supplements Industry.