**Maximization of cotton yields with balanced nutrition including foliar spraying of nutrient solution**

**ABSTRACT**

The Krishi Vigyan Kendra (KVK) in Bhadradri Kothagudem, Telangana conducted Front Line Demonstrations (FLD) on soil test based fertilizer application including foliar spraying of need based nutrient solution (MgSO4/ 19: 19: 19/ KNO3) during the *Kharif* seasons of 2019, 2020, and 2021 within its operational area. These demonstrations compared the effectiveness of recommended dose fertilizers application (N, P2O5, K2O) and soil test based fertilizer recommendation. The results showed that the soil test based fertilizer recommendation plots had higher cost-benefit ratios (B: C Ratio) of 1:1.94, 1: 2.41 and 1: 1.24 compared to the B: C ratios of 1: 1.39, 1: 1.85 and 1: 0.42 in normal recommended dose fertilizers application plots during the corresponding years.

**Key words:** Cotton, recommended dose, soil test, foliar spray

# Introduction

Often referred to as "White Gold," cotton (*Gossypium sp*.) is a major cash crop that significantly influences global economic and social standing. Cotton lint, an essential textile fiber comprises roughly 35% of total world fiber use (USDA, ERS, 2011). Transgenic cotton is growing geometrically in area. However, because fertilizer management significantly affects cotton production's profitability, farmers are becoming increasingly concerned about the rising costs of fertilizers and other inputs (Bazen *et al.,* 2007). Additionally, cotton farming is currently proving to be a less profitable endeavor, mostly due to the high production costs brought on by the careless use of fertilizers and pesticides. (Tayade and Dhoble, 2010). Even with a superior hybrid or genetically modified crop, it is challenging to expect depleted soils to support bumper crops or yield high growth rates under the current regime of widespread negative nitrogen balances. Agricultural system sustainability has grown in importance in emerging nations like India. Long-term tests in Asia have shown a steady decline in output due to the exhaustion of agricultural production systems caused by decades of overexploitation of soils. (Bhandari *et al*., 2002) (Ladha *et al*., 2003) (Manna *et al*., 2005). The projected crop yield response to nutrient application, which depends on crop nutrient requirements, the availability of nutrients from local sources, and the fertilizer's fate, must be understood in order to make an informed decision about fertilizer use (Dobermann *et al.,* 2003). The idea of "soil test based fertilizer recommendation" in the age of precision agriculture unifies the hotly contested strategies of "fertilizing the soil" versus "fertilizing the crop," guaranteeing actual balance (not just apparent balance) between the nutrients from the applied fertilizer and the nutrients found in the soil. Among the many techniques for determining fertilizer recommendations, the soil test based fertilizer application can distinctive in that it not only suggests a fertilizer dosage based on soil tests but also the amount of yield the farmer can anticipate if a good cultivation package is followed (Velayutham, 1979). Fertilizer is one of the most important and expensive inputs in agriculture and the application of correct amount of fertilizer is primary prerequisite for farm profitability and environmental safety (Kimetu et al, 2004). In India, fertilizers are generally applied to crops on the basis of generalized state level fertilizer recommendations, though the nutrient requirement of crops vary from place to place even for the same crop, as the fertility is highly variable chemical property of the soils. Fertilization of crops based on generalized recommendation leads to under fertilization or imbalanced fertilization, results in lower productivity, profitability along with environmental pollution.

1. **Materials And Methods**

The present study was undertaken at ten different farmers fields of Bhadradri Kothagudem district of Telangana with two treatments T1: Soil test based fertilizer application including foliar spraying of nutrient solution (technology demonstration) and T2: Farmers practice (without soil testing or check). The experiment was conducted consecutively for three years *i.e.* during *Kharif* season of 2019, 2020 and 2021. The methodology for the Front Line Demonstrations (FLD) followed guidelines outlined by Choudhary (1999) including experimental design, site selection, farmer selection, demonstration layout, and farmer participation. Agronomic practices were rigorously applied, with the cotton variety Shri ram cultivated in plots sized at 0.4 hectares across ten locations for each treatment. The recommended dose of fertilizer is 120:60:60 kg / ha of N, P2O5, K2O for cotton. This soil test-based fertilizer application to soil as well as foliar spray of 1 % MgSO4 / 19: 19: 19 / KNO3.

First soil is tested for pH, EC, N, P2O5 and K2O and based on test results fertilizers are recommended in different field during 2019, 2020 and 2021 (Table 1). Nitrogen, phosphorous and potassium were applied completely as basal dose at the time of sowing and mixed with soil. Urea, single super phosphate and Muriate of potash (MOP) were used as sources of N, P and K, respectively. From each plot five plants were selected and measured the plant height and number of bolls per plant. Finally, after the harvest of the crop the seed lint weight was expressed in kg/ha.

**Table 1: Soil test based fertilizer recommendations in different at ten different farmers fields**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **S. No** | **Soil test results** | | | | | **Recommendations based on soil test (N:P2O5:K2O)** |
| **pH** | **EC** | **N** | **P2O5** | **K2O** |
| 1. K. Venkateswara Rao | 7.4 | 0.21 | 256 | 24.6 | 212 | 120:60:60 |
| 2. M. Venkatanarayana | 7.2 | 0.60 | 210 | 32.2 | 166 | 156:42:78 |
| 3. A. Nagabhushanam | 6.9 | 0.32 | 252 | 36.2 | 322 | 120:42:42 |
| 4. B. Rupla | 6.8 | 0.65 | 294 | 46.2 | 368 | 120:42:42 |
| 5. R. Saibabu | 7.1 | 0.68 | 264 | 42.2 | 260 | 120:42:60 |
| 6. B. Ramakrishna | 6.9 | 0.31 | 280 | 35.2 | 288 | 120:42:60 |
| 7. Narsimha Rao | 7.4 | 0.43 | 268 | 36.2 | 312 | 120:42:42 |
| 8. P. Somyya | 7.6 | 0.10 | 205 | 35.2 | 294 | 156:42:60 |
| 9. M. Murali | 7.1 | 0.18 | 264 | 22.2 | 312 | 120:60:42 |
| 10. K. Ramu | 7.2 | 0.55 | 276 | 18.2 | 368 | 120:60:42 |

**3. Results and Discussion**

**3.1 Plant height**

Soil test-based fertilizer application including foliar spraying of nutrient solution recorded higher plant height (139.5, 138.17 and 138.4 cm) compared to farmers' practice (124.48, 121.54 and 124.6 cm) during *Kharif* seasons 2019, 2020, and 2021, respectively (Table 2).

**3.2 Number of bolls per plant**

More number of bolls per plant were observed more in the T1- soil test based fertilizer application plots (38.2, 37.6 and 37.5) compared to T2-farmers practice (26.4, 25.9 and 27.1) during *Kharif* seasons 2019, 2020 and 2021, respectively (Table 3).

**3.3 Yield (kg / ha)**

Higher yield was observed in the T1-soil test based fertilizer application plots (2010, 2566 and 1424 kg / ha) compared to T2- farmers practice (1750, 2218 and 1236 kg /ha) during Kharif seasons 2019, 2020, and 2021, respectively (Table 4).

Comparing the all three years data, increase in yield observed in T2-soil test based fertilizer application was done compared to farmers practice T1. Compared to T1-farmers practice 14.8, 15.6 and 15.2 % yield improvement was observed in the T2-demo plot during *kharif* 2019, 2020 and 2021, respectively (Table 5).

Higher C: B ratio was observed in the T1-demo plot (1:1.94, 1:2.41 and 1:1.24) compared to T2-farmers practice (1:1.39, 1:1.85 and 1:0.42) during *Kharif* seasons 2019, 2020, and 2021, respectively (Table 5).

Applying plant nutrients based on soil tests aids in understanding higher comeback ratios and benefit-to-cost ratios because nutrients are applied proportionately to the amount of a given nutrient deficiency, and correcting the imbalance of nutrients in the soil helps to maximize the synergistic effects of balanced fertilization (Choudhary *et al*, 2019). It gives balanced fertilization and the ratio of applied nutrients to soil-available nutrients a scientific foundation (Ramamoorthy and Velayutham, 2011). Enhancing crop yield and preserving soil health would be best achieved by using nutrient management techniques based on soil test results to reduce the usage of chemical fertilizers.

Compared to soil test-based fertilizer application, farmers' farming practices were relatively more expensive. This might be due to application of fertilizers as per farmers choice without soil testing and high cost of DAP, and complex fertilizer. This cost was reduced in treatment soil test-based fertilizer application by applying limited quantity fertilizers as per soil test values. Simultaneously cost benefit ratio was higher with soil test-based fertilizer application (1:1.86) compared to farmers practice (1:1.22) because of lower cost of cultivation and improved yield with soil test-based fertilizer application. The results are in line with Bhargavi *et al*. (2006) who reported for groundnut production with fertiliser application based on a soil test and Jayalakshmi et al (2021) for rice production. Further, the results are in agreement with Ghaswa et al., (2019) who conducted Knowledge, Adoption and Constraints of Soil Health Card based Fertilizer Application in Ratlam District, MP.

**Table 2: Effect of soil test based fertilizer application along with foliar spraying of need based nutrient solutions on plant height (cm) of cotton**

|  | **Plant height (cm)** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Farmers plot** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Mean |
| **2019** | **T1- Demo** | 138.5 | 139.72 | 140.2 | 142 | 143.7 | 132.7 | 135.8 | 139.2 | 143.8 | 139.8 | 139.5 |
| **T2- Farmer practice** | 128.1 | 118.3 | 125.8 | 127.2 | 129.3 | 130.4 | 121.7 | 118 | 121.8 | 124.2 | 124.48 |
| **2020** | **T1- Demo** | 133.2 | 131.7 | 138.2 | 134 | 139.1 | 142.5 | 141 | 139 | 140 | 143 | 138.17 |
| **T2- Farmer practice** | 119 | 121.4 | 122.4 | 129.4 | 110.5 | 125 | 123 | 118.3 | 119.2 | 127.2 | 121.54 |
| **2021** | **T1- Demo** | 141 | 139.1 | 131.8 | 138 | 134.7 | 138.2 | 136.8 | 137.9 | 142.8 | 143.7 | 138.4 |
| **T2- Farmer practice** | 121.5 | 119.3 | 127.5 | 118.3 | 125.3 | 128.1 | 130.2 | 124.1 | 128.5 | 123.9 | 124.6 |

**Table 3: Effect of soil test based fertilizer application along with foliar spraying of need based nutrient solutions on number of bolls of cotton**

|  | **Number of Bolls per plant** | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Farmers | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **Mean** |
| **2019** | **T1- Demo** | 40.2 | 35.7 | 38.1 | 41.2 | 39.2 | 35.7 | 40.9 | 35.8 | 38.6 | 37.4 | 38.2 |
| **T2- Farmer practice** | 23.3 | 27.9 | 29.4 | 30.2 | 28.6 | 25.1 | 26 | 21.8 | 25.2 | 27.3 | 26.4 |
| **2020** | **T1- Demo** | 40.2 | 39.4 | 37.1 | 36.4 | 38.3 | 32.7 | 38.9 | 34.5 | 37.3 | 41.5 | 37.6 |
| **T2- Farmer practice** | 25.1 | 21.8 | 25.6 | 24.9 | 23.4 | 26.3 | 29.8 | 27.1 | 28.3 | 26.8 | 25.9 |
| **2021** | **T1- Demo** | 36.4 | 33.8 | 39.2 | 37.4 | 35.8 | 38.9 | 35.1 | 38.7 | 41.7 | 38.1 | 37.5 |
| **T2- Farmer practice** | 26.8 | 24.1 | 28.1 | 24.7 | 26.3 | 25.8 | 27.3 | 29.3 | 28.3 | 30.7 | 27.1 |

**Table 4: Effect of soil test based fertilizer application along with foliar spraying of need based nutrient solutions on yield (kg ha-1) of cotton**

|  | Yield (kg ha-1) | | | | | | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Farmers** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | Mean |
| **2019** | **T1- Demo** | 2250 | 1900 | 2350 | 1750 | 1880 | 1800 | 1700 | 2100 | 2200 | 2170 | 2010 |
| **T2- Farmer practice** | 1875 | 1630 | 2150 | 1550 | 1625 | 1580 | 1650 | 1850 | 1850 | 1750 | 1750 |
| **2020** | **T1- Demo** | 2564 | 2586 | 2530 | 2570 | 2490 | 2650 | 2450 | 2660 | 2600 | 2560 | 2566 |
| **T2- Farmer practice** | 2206 | 2224 | 2200 | 2300 | 2200 | 2200 | 2030 | 2300 | 2150 | 2370 | 2218 |
| **2021** | **T1- Demo** | 1425 | 1392 | 1421 | 1454 | 1412 | 1360 | 1430 | 1418 | 1474 | 1454 | 1424 |
| **T2- Farmer practice** | 1220 | 1260 | 1290 | 1230 | 1180 | 1270 | 1230 | 1220 | 1180 | 1280 | 1236 |

**Table 5: Effect of soil test based fertilizer application along with foliar spraying of nutrient solutions on yield and C:B ratio of cotton**

| **Year** | **Yield(kg ha-1)** | | **Yield**  **Improvement (%)** | **C:Bratio** | |
| --- | --- | --- | --- | --- | --- |
| **Demo** | **Check** | **Demo** | **Check** |
| **2019** | 2010 | 1750 | 14.8 | 1: 1.94 | 1:1.39 |
| **2020** | 2566 | 2218 | 15.6 | 1: 2.41 | 1:1.85 |
| **2020** | 1424 | 1238 | 15.2 | 1:1.24 | 1:0.42 |
| **Mean** | 2000 | 1735 | 15.2 | 1: 1.86 | 1:1.22 |

**4. CONCLUSION**

Based on the findings of this study, it can be inferred that soil test based fertilizer application in cotton results in higher yield as compared to normal recommended dose of fertilizer application in cotton. Yield improvement of 14-15 % observed in T1 (soil test based fertilizer application plot) compared to T2 (normal recommended dose of fertilizer application plot), Which resulted in increase in the net returns of farmers. The Front Line Demonstration (FLD) intervention has proven highly effective in enhancing cost benefit ratio among farmers. The positive outcomes observed in technology demonstrated plots warrant wider implementation across the Bhadradri Kothagudem district. These results can be leveraged to encourage farmers to adopt these practices, thereby reducing unnecessary and unwarranted usage of fertilizer and reduce the soil pollution.

**6. REFERENCES**

1. Bazen, E . F., Larson, J. A., Roberts, R. K. Economics of fertility management in cotton production in the United States, *Dynam. Soil Dynam. Plant* 1, 2007, 95–104.
2. Bhandari, A. L., Ladha, J. K., Pathak, H., Padre, A. T., Dawae, D., Gupta, R.K. Yield and soil nutrient changes in a long-term rice–wheat rotation in India, Soil Sci. Soc. Am. , 58, 2002, 185–193.
3. Bhargavi K, Padmalatha Y, Vijaya Sankara Babu M. Nutrient management of groundnut through farmers participatory approach. National Symposium on conservation Agriculture and Environment, October 26-28, 2006. BHU, Varanasi;.
4. Choudhary, B. N. Krishi Vigyan Kendra-A guide for KVK managers. Division of Agricultural Extension, ICAR. 1999., pp 73-78.
5. Choudhary S, Baghel S S, Upadhyay A K and Singh A. STCR- Based Manure and Fertilizers Application Effect on Performance of Rice and Chemical Properties of Vertisol. Int J Curr Microbiol App Sci. 2019.8(3): 2080-2086.
6. Dobermann, A., Witt, C., Abdulrachman, S., Gines, H.C., Nagarajan, R., Son, T.T., Tan, P.S., Wang, G.H., Chien, N.V., Thoa, V.T.K. Soil fertility and indigenous nutrient supply in irrigated rice domains of Asia, Agron. J., 95, 2003, 913-923.
7. Ghaswa, R., Tripaty, S., & Sharma, B. Knowledge, Adoption and Constraints of Soil Health Card based Fertilizer Application in Ratlam District, MP. Indian Journal of Extension Education, 2019. 55(2), 94-96
8. Kimetu, M., Mugendi, D. N., Palm, C. A., Mutuo, P. K., Gachengo, C. N., Nandwa, S., & Kungu, B. 2004. African network on soil biology and fertility. pp 207-224.
9. Jayalakshmi, M. Prasadbabu, G. Chaithanya B. H., Bindhupraveena R. and Srinivas T. Impact of Soil Test Based Fertilizer Application on Yield, Soil Health and Economics in Rice Indian Journal of Extension Education.2021. 57( 4),147-149
10. Ladha, J. K., Dawe, D.,Pathak, H.,. Padre, A.T., Yadav, R.L., Singh, B., Singh, Y., Singh, P., Kundu, A.L., Sakal, R., Ram, N., Regni, A.P., Gami, S.K., Bhandari, A. L., Amin, R., . Yadav, C.R., Bhattarai, E.M., Das, S., Aggarwal, H.P., . Gupta, R. K., Hobbs, P. R.How extensive are yield declines in long-term rice–wheat experiments in Asia? Field Crops Res., 81, 2003, 159-180.
11. Manna, M. C., Swarup, A., Wanjari, R.H., Ravankar, H.N., Mishra, B., Saha, M.N., Singh, Y.V., Sahi, D.K., Sarap, P.A. Long-term effect of fertilizer and manure application on soil organic carbon storage, soil quality and yield sustainability under sub-humid and semi-arid tropical India, Field Crops Res., 93, 2005, 264–280.
12. Ramamoorthy B and Velayutham M. The Law of optimum‖ and soil test based fertilizer use for targeted yield of crops and soil fertility management for sustainable agriculture. Madras Agric J.2011. 98: 295-307.
13. Tayade, A. S., Dhoble, M. V. Effect of transgenic cotton hybrid, nutrient and pest management on seed cotton yield, nutrient uptake and status of available nutrient in soil, *Indian J. Fert.*, 6(8) 2010, 34- 40
14. United States Department of Agriculture, Economic Research Service. 2011. <http://www.ers.usda.gov/Briefing/Cotton/> (accessed 18.07.11).
15. Velayutham, M. Fertilizer recommendation based on targeted yield concept, problems and prospects, *Fert. News.*1979*,* 24(9)12-20.