MM 2.1 Integrated nutrient management for high quality fibre and yield

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Target & Achievement

Target / activity	Achievement (during 2004-05)
Rotation crop data (April-May 2004)	Yield and yield attributes for the rotation crop at Hisar, Sriganganagar (wheat) and Abohar (chickpea) were recorded. In the first year of the trial, residual effects of nutrient management practices were not significant. However, yields were greater in plots amended with FYM were greater than those without
Soil analysis of samples collected at end of first season (2004)	**A-** Soil samples were analysed at seven of the eleven locations. In general, differences were not significant at most locations. **B-** In addition, soils were analysed for micronutrients at Hisar and Coimbatore. **C-** Treatments with Zn, registered higher DTPA extractable Zn in the soil
Field evaluation repeated for the second year on INM	**A-** Field experiments were successfully conducted at twelve locations (five in the north zone, four in the central zone and three in the south zone). **B-** Nutrient uptake was determined at nine centers. **C-** Nutrient balance was constructed, taking into account the nutrient uptake for the cropping system as a whole
Field evaluation of foliar application of potassium	Field experiments conducted successfully at ten locations. Significant response to K application was noticed at seven locations.

- **Effect of nutrient management practices on growth, yield and fibre quality**

Field experiments were conducted at twelve locations to evaluate the effect of nutrient management practices on the seed cotton yield and fibre quality.

The treatments included

1. Absolute control
2. Application of recommended dose of fertilizers
3. RDF + zinc application (zinc sulphate 20 kg/ha)
4. RDF + B spray (0.1% B twice at flowering and boll formation) ($MgSO_4$ at Dharwad and $FeSO_4$ spray at Ludhiana and Hisar)
5. RDF + Zn + B ($MgSO_4$ at Dharwad and $FeSO_4$ at Hisar and Ludhiana)
6. 50% nutrients through organic and 50% through inorganic
7. 25% nutrients through organic and 75% through mineral fertilizers
8. Target yield/ site specific nutrient management

Treatments 1 to 7 were included at all the centres. Additionally treatment 8 was included at CICR, Nagpur and TNAU, Coimbatore. The site-specific nutrient management approach was adopted following the procedures of Dobermann et al. (1997). At IISS, Bhopal the targeted yield approach using the target yield equations was followed.

Site-specific nutrient management plan is to focus on the indigenous nutrient supply and temporal variability in crop demand. A linear optimization procedure was used to find the optimal fertilizer rate to achieve the yield goal. With this approach, cost on fertilizer can be reduced. Already target yield equations were developed, however, very little is known about it on cotton. Therefore, IISS has included this treatment for validating its use in cotton.

At Dharwad centre, $MgSO_4$ spray was taken in place of B. While at two locations in the north zone (Hisar and Ludhiana), $FeSO_4$ was sprayed in place of B taking into consideration that B is supplied through irrigation water and the high soil B status. At all locations, every treatment had three replications.

Details of the cropping systems for each centre is given in Table 2.1.1 & 2.

Table 2.1.1 Details of the cropping systems

S. No.	Location (s)	Cropping system
Irrigated north zone		
1	Abohar, Ludhiana, Hisar, Sriganganagar	Cotton – wheat
Rainfed central zone		
2	Nagpur, Parbhani	Cotton, cotton – soybean
3	Surat	Cotton, Cotton + mung
4	Bhopal	Cotton – soybean/wheat
5	Banswara	Cotton, cotton + soybean
Rainfed southern zone		
6	Guntur	Cotton- cotton, cotton + soybean
7	Dharwad	Cotton- cotton, cotton– soybean/chickpea
Irrigated southern zone		
8	Coimbatore	Cotton - brinjal

Table 2.1.2. Cultivars of cotton and the recommended dose of fertilizers given to cotton

Sl. No.	Location	Cotton cultivar	Recommended dose of N-P-K (kg/ha)
1	Sriganganagar	RS – 2013	80-17-17
2	Hisar	H – 1226	80-13-0
3	Ludhiana	LH 1556	75-13-25
4	Abohar	LH 1556	75-13-25
5	Banswara	H-6	120-21.5-32
6	Nagpur	NHH-44	90-19-37
7	Bhopal	H-8	80-17-16
8	Parbhani	PH-348	80-17-33
9	Surat	G. Cot. Hy – 10	240-0-0
10	Guntur	Narsimha	90-19-37
11	Dharwad	DHH-11	80-17-33
12	Coimbatore	Paras Attal	120-26-50

At Surat, Banswara and Guntur locations involving intercropping systems; a split plot design was adopted with the cropping systems assigned to the main plots and nutrient management practices to the sub-plots.

At Nagpur, Parbhani and Dharwad locations evaluating the response of nutrient management practices for a rotational cropping system, a split-plot design was adopted.

Data were statistically analyzed following appropriate designs and the treatment differences separated out using least significant difference at 5% probability.

- **To evaluate the effect of foliar application of potassium on seed cotton yield and fibre quality**

A field experiment was conducted in a randomized block design at eleven locations (Abohar, Ludhiana, Hisar, Sri Ganganagar, Banswara, Surat, Nagpur, Parbhani, Guntur, Dharwad and Kovilpatti). Except the three sites in the north zone, the experiment was conducted under rainfed conditions. In the north zone the crop was irrigated. The treatments included were as follows:

1. Recommended N, P (NP)
2. Recommended N, P, K (NPK)
3. Recommended N, P, K and foliar K at early boll formation (NPK + K1)

4. Recommended N, P, K and foliar K at peak boll formation (NPK + K2)
5. Recommended N, P, K and foliar K at early and peak boll formation (NPK + K3)

Results

Seed cotton yield and yield attributes

Seed cotton yield was significantly affected by nutrient management practices at all the locations **(Table 2.1.3)**. Seed cotton yield was the least in the control plot. With the application of recommended dose of fertilizers (RDF), seed cotton yield was significantly greater than the control plot.

North zone

Sri Ganganagar: Treatment RDF + Zn + B had significantly better yield than the treatments RDF, RDF + B and supplying 25% through organic and 75% through inorganic sources. RDF + Zn + B treatment was on a par with the RDF + Zn and the plots receiving 50% through organic and inorganic sources. Plots fertilized with 50% organic manure could have met some of the Zn and S demand of the crop and was significantly better than the RDF alone. At this centre, ***Zn could be a critical limiting nutrient***. Soil Zn status was lower than the critical limit. Response to application of B was not observed. Probably irrigation water may supply the crop B needs. Yield contributing characters followed a similar trend. The soil at the site was high in P and K whereas it was very low in N and organic C.

Hisar: Differences between the fertilizer treatments were significant. Highest seed cotton yield was obtained in the plots fertilized with NPK and S (**Table 2.1.3**). Response observed to Zn application was because of supply of S. No significant response was observed to the application of Zn and Fe. Basically, ***Hisar soils are deficient in S*****,** and therefore, at this location it is imperative to apply S. ***Pressmud as an organic amendment in combination with mineral fertilizers was found to be equally good*** to mineral fertilizers alone (NPK).

Abohar: Seed cotton yield and yield attributes were significantly lesser in the control plots compared to the fertilized plots (**Table 2.1.3**). Differences between fertilizer treatments were not significant. However, plots receiving zinc had 10.0-10.6% greater yield than the plots receiving RDF.

Ludhiana: Field trial was conducted for the first year. Differences were significant in the yield between the fertilized and control plots. yield in the plots partially substituted with organic manure were not significantly different than the RDF. All the fertilized plots were on a par. Similar to the data recorded at Abohar, yield in the zinc supplied plots was 144 kg greater than the RDF. Trends for boll number were similar to the yield. Boll weight was not affected by the treatments.

Central Zone

At **Banswara**: Combined application of Zn and B in the greatest seed cotton yields and were significantly greater than NPK, NPK + Zn, NPK + B and the plots supplied with FYM in combination with inorganic fertilizers (**Table 2.1.3**). ***Response to zinc application was significant suggesting the residual effects of Zn***. Foliar application of B increased yield by 141 kg over RDF and differences were significant. Comparing cropping systems, seed cotton yield was lower in the intercropped plots compared to the monocropped cotton plots. However, cotton equivalent yields were significantly higher than the sole cropped cotton. Additional 339 to 634 kg of cotton equivalent per hectare could be realized by intercropping cotton with soybean. A trend similar to that observed for yield was observed for the yield attributes and plant growth characters.

Surat: at this location, differences in productivity were significant between cropping systems (Cotton sole vs. cotton + mung intercropping). Productivity was significantly higher in the intercropped plots than the sole cotton plots. Mean cotton equivalent of the intercropped plots was 1688 kg/ha compared to 1140 kg/ha in the sole cotton plot.

Differences were highly significant between nutrient management practices (Table 2.1.3). Fertilizer applied plots had yield significantly greater than the control plot. The treatments RDF, RDF + Zn and RDF + B were similar. Plots receiving organic manure yielded the highest, and were similar. Substitution of 25% N through organics resulted in significantly greater yield than the recommended fertilizer N alone (240 kg/ha). Differences between recommended NPK and recommended N were not significant

Nagpur: Seed cotton yield was greater in the plots following soybean than the cotton-cotton monoculture. Between the nutrient management practices, fertilized plots had significantly higher seed cotton yield than the control plot (Table 2.1.3). With the combined application of Zn and B, yield increased by 7.7% (+126 kg) over RDF alone. However, differences were not significant. Plots with partial substitution of N by organic manure resulted in yields on a par with the mineral fertilizer plots (RDF). Plots with 25% N substitution had lower yields compared to 50%. Cumulative effects of organic manure are expected to be larger with greater amounts of organic manure applied. Seed cotton yield was the highest with the site-specific nutrient management approach. Yield target of 15 q/ha was exceeded by 4.5 q. Furthermore; in the SSNM plots 15 kg less N was applied. However, additional cost would be incurred on supplying P and K at amounts greater than those recommended. But the yield increase of 450 kg seed cotton over the RDF plots would cover the cost of additional P and K fertilizer and labour charges towards spraying of DAP. The soils at Nagpur are ***deficient in P and Zn and very low in organic C***. Therefore, to realize potential seed cotton yields; ***applying sufficient P and Zn would be essential***. Although no significant response to Zn was observed, it does not mean that there is no necessity to apply these nutrients. Less than normal rainfall was received and the availability of Zn may have been lowered.

Parbhani: Differences between cotton monoculture and cotton-soybean systems were not significantly different. However, it is to be realized that this is just the first year of study. Cropping system effects take time to reflect the changes. Between nutrient management practices, ***maximum seed cotton yield was recorded in the RDF + Zn + B treatment followed by RDF + Zn*** and were significantly better than RDF (NPK alone) (Table 2.1.3). Over RDF, yield increase with the application of Zn was 236 kg/ha whereas combined application of Zn and B yielded 329 kg more seed cotton. Although response to application of foliar B was significant (RDF + B vs. RDF), yield increase was 139 kg over RDF. All fertilized plots had yield significantly higher than the control plots.

At **Bhopal**, seed cotton and above ground biomass yields were significantly affected by nutrient management practices. Data on seed cotton yield are presented in Table 3. Application of NPK either alone or Zn and/or B and

integrated use of fertilizers and FYM caused a significant increase in seed cotton yields over the control. Yields obtained with NPK plus Zn and/or B were greater than those with NPK alone, ***indicating the importance of Zn and B***. Zinc, boron and combined application of zinc and boron resulted in 16, 9 and 21% increased yields over NPK. Similarly, substitution of 50% N through FYM . In target yield approach, a yield target of 15 q seed cotton/ha was fixed. This treatment out-yielded the target and was at par with RDF through fertilizers (T2). The favourable rainfall conditions resulted in high yield levels. The soil status of zinc and boron are below the critical limits and this explains the positive response to application of zinc sulphate and foliar sprays of B. All the fertilizer treatments caused a significant increase in the plant growth and yield attributes.

South zone

At **Guntur**, no significant difference was observed between cropping systems (cotton sole vs. cotton + soybean intercropping). Mean seed cotton yield averaged over treatments was 1577 kg/ha in the sole cotton plots and 1409 kg/ha when intercropped. These results highlight that ***soybean can be grown as an intercrop without any significant adverse affect on cotton***. The cotton equivalent yield in the intercropping system was 1577 kg/ha. Thus on equivalent basis, the two systems did not differ Significant differences were noticed with the application of nutrients (Table 2.1.3). Significant interaction effect was observed. Averaged over cropping systems, yield was the greatest with 25% N through organic + 100% through fertilizers followed by 50% through organic and inorganic and 25% through organic and 75% through inorganic and all were on a par. They were significantly better than the NPK alone.

The data significantly points out that when cotton is intercropped with soybean, application of recommended dose of fertilizer is sufficient. Probably, soybean a legume crop might have transferred additional N to the cotton crop. This needs to be studied.

At **Dharwad** No significant differences were noticed between fertilized plots. Yield in the plots supplied with Zn was lesser than the NPK and other treatments (Table 2.1.3).

Coimbatore: The crop was irrigated and cotton-brinjal was the cropping sequence followed. Treatment RDF + Zn + B plots had the highest seed cotton yields and was at par with the 50% organic and 50% inorganic sources of N. Seed cotton yield for the SSNM treatment was significantly greater than the RDF and RDF + B plots. In the SSNM approach, a saving of 45 kg P_2O_5 and 45 kg K_2O could be obtained. Soils of Coimbatore have a very high exchangeable K content and therefore the indigenous supply is sufficient to meet the crop demand. **Adoption of SSNM could result in savings on fertilizers**. A small amount of P and K needs to be applied although the soils are rich in P and K, as a starter to meet the initial demand of the cotton seedlings.

- **Effect of nutrient management practices on fibre quality**

Ginning outturn

In general, fibre quality was not significantly affected by the nutrient management practices. Ginning outturn (GOT) was significantly affected by nutrient management practices at one of the 9 locations where GOT was determined. At Sri Ganganagar, GOT was higher in the RDF + Zn + B plots than the RDF alone. At most of the locations, in general, Zn applied plots resulted in significantly greater GOT than the RDF plots. The Zn applied plots were followed by the partial substitution of 50% N through organics and were better than the NPK alone plots

Fibre length

Significant differences between treatments were recorded at Banswara, Parbhani, Guntur and Dharwad. At all these locations, zinc applied plots had significantly better fibre length than the NPK alone. Amending soil with organic manure, resulted in significantly greater fibre length than the NPK at Guntur, Dharwad and Banswara.

Fibre strength

Zn + B and Zn applied plots had a better fibre strength at Banswara, Bhopal and Parbhani, bnut the differences were significant at Banswara. At Guntur, compared to RDF, partial substitution of 50% N through organic resulted in a significant improvement in fibre strength.

Micronaire

At Surat, fibre fineness was affected by nutrient management practices. Micronaire values were the largest in the control plots and in general were greater than the fertilized plots. Between fertilizer treatments, NPK plots had less fine fibres than the organic manure amended plots. Similarly, at Banswara, micronaire values in NPK plots were lesser than the organic manure and NPK + Zn treatments.

Uniformity

With regard to fibre uniformity, differences were significant only at Banswara. Zn application resulted in a better uniformity than the NPK alone plots.

Effect of foliar application of potassium on seed cotton yield

Response to foliar application of potassium at either early or peak boll formation stages was evaluated in field experiments at seven locations under rainfed conditions. Besides rainfed cotton, response to foliar-K was also evaluated at four locations in the irrigated cotton-wheat double crop system in the north zone.

The **hypothesis for this experiment** was that potassium requirement is higher at the boll formation stages and uptake is limited under rainfed conditions. Since K plays an important role in fibre development and translocation of carbohydrates, supplying the crop with potassium through foliar spray could possibly meet the crop demand when uptake process has slowed.

Rainfed Central Zone

In the **Central zone**, significant response to application of potassium was observed at Nagpur, Banswara and Parbhani (Table 2.1.4). Differences were not significant at Surat.

At Parbhani, seed cotton yield increased significantly with two sprays of KCl at early and peak boll stages in addition to soil application over soil applied NPK. Application at either early or peak boll stages did not result in significant yield advantage over NPK soil application.

Nagpur: Yield in the NPK + K3 treatments (two foliar sprays) was the highest and was significantly greater than the other treatments (Table 2.1.4). Yield in the without K plots was the least and was significantly lesser than those with K. Response to K applied to soil over without K treatment was 27.8%. Yield

increases recorded in the K applied plots was mainly because of an increase in boll number. In addition to *G. hirsutum*, response of *G. arboreum* cotton to foliar application was also studied. The data indicates significant response to soil application of K over the NP plots (Table 2.1.5). Between fertilizer plots, foliar-K twice at early and peak boll stages resulted in a 357-kg more yield than the NPK. Treatments NPK, NPK + K1 and NPK + K2 were on a par. Boll number between treatments were not significantly different between treatments (96 to 115 bolls m^{-2}). However, K applied plots had a significant increase in boll weight. Although the soils were high in exchangeable-K content, a significant response to K was observed. In the previous year, response was not significant.

Table 2.1.5 Response of *G. arboreum* cotton to foliar-K application

Treatment	Seed cotton yield (kg/ha)	Total K uptake (kg/ha)	K balance (kg/ha)
NP	767	39.8	-39.8
NPK	1061	59.0	-34.0
NPK + K1	935	60.1	-31.1
NPK + K2	1098	77.1	-48.1
NPK + K3	1440	92.4	-59.4
LSD ($p<0.05$)	278	20.6	NS

K uptake was significantly greater in the K applied plots compared to those without both for *G. hirsutum* (Table 2.1.6) and *G. arboreum* (Table 2.1.5). Consequently, K balance was negative, irrespective of K application.

At Banswara, response to application of potassium was significant (Table 2.1.6). Foliar spray at early and peak boll stages in addition to soil application resulted in yield increase of 65 kg/ha over the NPK treatment.

Rainfed southern zones

In the **south zone**, treatment differences were significant at all three locations. At Guntur, yield was the greatest in NPK + K3 and was on a par with one spray and significantly greater than NPK alone. Differences between NPK and NP were not significant. At Dharwad, differences were not significant between the soil and soil + foliar methods. Yield of the K treated plots was significantly greater than the NP. At Kovilpatti, yield levels were the lowest. Application of K through

foliar spray at early and peak boll stages resulted in significantly greater yield than the NP plots. Differences between the K supplied plots (soil and soil + foliar) did not differ significantly.

Irrigated north zone

In the **North zone**, significant response to application of K (NPK) was noticed (Table 2.1.4) at Abohar and Sri Ganganagar. Application of foliar K did not result in significant yield improvement over the soil applied K (NPK).

K uptake

Data available for the four locations under rainfed conditions indicated significant increase in K uptake with fertilizer-K application at Nagpur, Parbhani and Banswara (Table 2.1.6). Application of foliar spray, further increased the K uptake.

Out of four locations in the north irrigated cotton; data is available for Hisar and Sri Ganaganagar (Table 2.1.6). At Hisar, differences were not significant. On the other hand, at Sri Ganganagar, K applied plots had greater K uptake than those without. Between K treatments, twice-sprayed plots had more uptakes.

Effect of K on fibre quality

Ginning outturn : At Parbhani and Guntur significant increase in GOT was noticed with K application . Improvement in GOT by foliar application of K was also noticed at Parbhani and Guntur but the differences were significant at Parbhani. At Dharwad centre, foliar application of K at peak boll and at early and peak boll formation improved the GOT over the NP plots in the previous year (2003-04). No such difference was noticed this year. The previous year was a dry year, and the data suggests that K application could be crucial in low rainfall years.

In the irrigated north zone, differences were significant at Sri Ganganagar. The K applied plots had significantly better yield than the plots without K.

Fibre quality A significant effect of K application on fibre quality parameters (fibre length, strength, fineness and uniformity) was noticed at two locations namely, Banswara and Guntur. At Banswara, fibre length, strength, and uniformity were significantly improved with K application. Fiber strength values were less than 20 g/tex in the NP and NPK plots and therefore, are classified as weak. Fineness was lower in K applied plots (higher micronaire

values) than the plots without K. At Guntur, fibre length and strength was significantly improved with the application of two foliar sprays compared to NPK alone. Fibre length increased by 9.7% and strength by 11.5% over the NPK plots.

- **Nutrient uptake as affected by nutrient management practices NPK uptake**

Data available for 8 out of the 12 locations indicated that without exception, nutrient uptake was greater in the fertilized plots than the control plots. The fertilized plots had the highest seed cotton yield and the component crops, thus resulting in the highest nutrient uptake. Nutrient uptake is a function of the yield levels (seed cotton, grain and stalks). The nutrient uptake since it was very closely related to the yield level, the pattern followed was similar to the yield trend at all the locations.

Between locations, uptake was the greatest in the irrigated cotton in the north and at Coimbatore compared to the rainfed cotton at other locations. Among the rainfed centers, P uptake was very low at Bhopal and Nagpur centres. These soils have very low P content and high P fixing capacity and P is a major yield constraining factor at Bhopal and Nagpur.

Cotton plant parts were analyzed separately for the nutrient content . Most of the N and P were concentrated in the seed, while K concentration was the greatest in carpel wall followed by stem and leaf. Because of the fertilizer treatments, nutrient concentrations were significantly better in the plots well supplied with the nutrients compared to the control plot at all the locations. A higher nutrient concentration and higher yields resulted in higher nutrient uptake. At Hisar location, sulphur and zinc were estimated. Expectedly S fertilized plots had higher S content than the plot without S. Sulphur uptake was greater in the S applied plots than the control plot .

Micronutrient uptake

Boron and zinc contents were determined at Coimbatore. The zinc and boron contents were higher in plots supplied with these nutrients thus resulting in greater uptake of zinc and boron .

- **Component crop yield**

Inter-cropping systems

Intercropping compared to sole cotton was followed at three locations, namely Guntur, Surat and Banswara. At Surat, moong was grown as an intercrop between cotton rows. Moong grain yield was not affected by the treatments. Grain yield ranged from 838 to 1027 kg/ha . At Guntur and Banswara, soybean was grown as an intercrop between cotton rows. Lsb-1 was the cultivar grown at Guntur. Grain yield was significantly better in the fertilized plots compared to the control plots . Furthermore, soybean grain yield was significantly greater in the 25% organic + 100% inorganic (T8 treatment) than the RDF treatments and was on a par with the organic manure amended plots. This indicates that when cotton is supplied with organic manure, it benefits the component intercrop. At Banswara, soybean grain yield was greater in the plots supplied with Zn and organic manure with significant yield increase ranging from 1-1.8 q/ha

Rotational crop yields

At two locations, a cotton-soybean two-year rotation was followed. While at Bhopal and Dharwad, cotton was followed by a double crop. At Bhopal the cotton crop was followed by soybean-wheat, whereas at Dharwad it was soybean-chickpea.

Nagpur: Differences between treatments were significant. Soybean grain yields were higher in the SSNM plots and plots receiving Zn compared to RDF alone and control plots.

At Parbhani, treatment differences were not noticed with regard to the soybean grain yield.

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to the control plot . Furthermore, soybean grain yield was significantly greater in the 25% organic + 100% inorganic (T8 treatment) than the RDF treatments and was on a par with the organic manure amended plots. This indicates that when cotton is supplied with organic manure, it benefits the component intercrop. At Banswara, soybean grain yield was greater in the plots supplied with Zn and organic manure with significant yield increase ranging from 1-1.8 q/ha

Rotational crop yields

At two locations, a cotton-soybean two-year rotation was followed. While at Bhopal and Dharwad, cotton was followed by a double crop. At Bhopal the cotton crop was followed by soybean-wheat, whereas at Dharwad it was soybean-chickpea. Grain yields for the rotation crops are presented in (Table 2.1.7).

Nagpur: Differences between treatments were significant (Table 2.1.7). Soybean grain yields were higher in the SSNM plots and plots receiving Zn compared to RDF alone and control plots.

At Parbhani, treatment differences were not noticed with regard to the soybean grain yield.

Table 2.1.7. Rotation crop yield (kg/ha) in the rainfed cotton cropping systems (two-year rotation)

Treatments given to previous crop (cotton)	Nagpur	Parbhani	Bhopal		Dharwad	
			Soybean	Wheat	Soybean	Chickpea
Control (T1)	716	1618	492	3223	723	1114
RDF (T2)	1390	1729	544	3505	857	1265
RDF + Zn (T3)	1161	1785	576	3774	831	1386
RDF + B (T4) [a]	1411	1742	546	3564	776	1232
RDF + Zn + B (T5)	1914	1813	570	3664	902	1356
50% through organic and inorganic (T6)	1237	1748	663	3933	884	1448
25% + 75% org. inorganic (T7)	1230	1741	629	3521	849	1600
SSNM (T8) [a]	1862	-	597	3572	839	1345
LSD (5%)	377	NS	70	NS	129	340

[a] Dharwad: T4 and T5: $MgSO_4$ (1%) was sprayed instead of B and in T8 cotton crop received 25% N through manure + 100% RDF

Bhopal: Soybean (cv. JS 335) in *kharif* and wheat (cv. WH 147) in *rabi* were grown with recommended dose of fertilizers in the same field layout used for cotton the previous year. Grain yields and yield attribute of soybean showed a residual influence of Zn and FYM used for the previous cotton (Table 2.1.7). Soybean grain yield was the highest with INM treatment (T6). In contrast, there was no residual effect of fertilizer management practices of cotton on the wheat grown after soybean in second year. However, productivity tended to be greater with the INM treatments applied to cotton.

Dharwad: At Dharwad centre, soybean grain yield was significantly influenced by nutrient management practices imposed on the previous year cotton crop. Grain yield differences were between the control plots and the fertilized plots. Yield was greater in

plots fertilized with Zn. Similarly; chickpea grain yield was also significantly influenced by nutrient management practices with significant differences between the fertilized and control plots. Differences between the fertilizer treatments were not significant. However, grain yields were greater on plots amended with organic manure.

In the irrigated north zone, double cropping is commonly practiced and cotton is followed by wheat. At four locations, data on wheat grain yield was recorded along with the nutrient uptake. Data pertains to year 1 (2003-04). Grain yield differences were not significant at any of the locations. However, yields were greater in the plots receiving organic manure.

- **Nutrient uptake of the entire cropping system**

More intensive the cropping system, greater is the nutrient uptake and is an index of the load or stress that is put upon the soil resources.

- **Soil nutrient availability**

Nutrient management practices significantly influenced the nutrient availability in post-harvest soil (Table 2.1.8 to 10) at Bhopal and Coimbatore locations.

At Bhopal the available N (Table 2.1.8), $NaHCO_3$ extractable P (Table 2.1.9) and exchangeable K (Table 2.1.10) was similar in the fertilized plots and was significantly greater than the control.

At Surat, N availability was not significantly affected by the nutrient management practices in the surface (0-22.5 cm) and sub-surface layers (22.5-45 cm). Available P (Table 2.1.8) and exchangeable K (Table 2.1.9) were greater in plots receiving NPK in recommended amounts followed by the organic manure amended plots.

At Coimbatore, macronutrient status was significantly greater in the fertilized plots (Table 2.1.8 to 10) and similar pattern was noticed for the micronutrient Zn (Table 2.1.11). Differences for hot water extractable B was not significant (Table 2.1.10). With regard to available P and exchangeable K, higher contents were recorded in plots that were supplied with organic manure. Zn content was significantly greater in the plots amended with $ZnSO_4$. Available Zn content was significantly lesser in the control plots than the fertilized plots. Reasons for these need to be ascertained.

Table 2.1.8. Soil N availability (kg/ha) as affected by nutrient management practices

	Bhopal	**Surat**	**Coimbatore**
Control	169	252	125
RDF	199	264	244
RDF + Zn	193	244	248
RDF + B	196	238	248
RDF + Zn + B	192	260	250
50% organic and inorganic	207	256	258
25% + 75% organic + inorganic	199	267	247
Target yield	187	264	264
LSD (0.05)	12	NS	9

Table 2.1.9 Soil P availability (kg/ha) as affected by nutrient management practices

	Bhopal	**Surat**	**Coimbatore**
Control	8.5	21	17.0
RDF	14.3	21	45.8
RDF + Zn	12.8	23	44
RDF + B	13.6	20	45.4
RDF + Zn + B	12.9	22	44.3

1:1 org.: inorganic	18.0	24	48.5
25% + 75% org. inorganic	16.7	21	47.9
Target yield	16.1	23	34.0
LSD (0.05)	2.1	2	1.5

Table 2.1.10 Soil exchangeable K (kg/ha) as affected by nutrient management practices

	Bhopal	**Surat**	**Coimbatore**
Control	499	533.6	984
RDF	529	514.4	1078
RDF + Zn	514	484.0	1074
RDF + B	525	517.9	1083
RDF + Zn + B	516	489.7	1078
1:1 org. :inorganic	551	517.9	1085
25% + 75% org. inorganic	532	593.5	1080
Target yield	509	654.9	1014
LSD (0.05)	34	88.6	37

Table 2.1.11 Micronutrient status in soil at the end of two cropping seasons in Coimbatore

	Zn (mg/kg)	**B (mg/kg)**
Control	0.87	0.66
RDF	1.17	0.70
RDF + Zn	3.15	0.68
RDF + B	1.15	0.70
RDF + Zn + B	2.83	0.72
50% organic + 50% inorganic	1.24	0.76
25% + 75% org. inorganic	1.22	0.75
SSNM	1.92	0.70
LSD ($p<0.05$)	0.08	NS

Soil nutrient balance

The balance sheet was worked out for N, P and K at harvest stage (Table 2.1.12). In general, positive balance was observed for N and K, while balance was negative for P. Among the treatments, SSNM had the highest (+) N balance followed by the organic manure amended plots. Similarly, N balance was highly positive in the control plots mainly because depletion by crop removal was low. A net negative balance was recorded in all treatments except those that received

organic manure. Organic manure may have released the P gradually into the labile pool. Gain of K was higher in treatments that received organic manure. K balance was negative in the control plots.

Plots receiving a combination of goat manure and fertilizers at Coimbatore, resulted in a positive nutrient balance.

Table 2.1.12. Soil nutrient balance (kg/ha) as affected by nutrient management practices at the end of cotton harvest (two cropping seasons) at Coimbatore

	N	**P**	**K**
Control	17	-1.86	-8
RDF	1	-1.54	9
RDF + Zn	13	-4.15	12
RDF + B	7	-4.64	24
RDF + Zn + B	11	-1.81	35
50% organic + 50% inorganic	13	2.11	29
25% + 75% org. inorganic	17	1.07	26
SSNM	18	-0.76	26

Project Impact:

- Nutrient budgets constructed should help in better nutrient management at different locations
- Monitoring the fruiting pattern and the growth (biomass) of cotton and nutrient analyses would help in determining the peak demand and portion of the plant nutrients located
- Site-specific nutrient management based on yield targets should reduce the nutrient loss and enhance profits
- Ultimately, location specific nutrient module / strategy will be developed. This would directly aid in improving productivity.