# Impact of Crop Management and Soil-Site Parameters on Growth and Yield of Cotton

S.C. YADAV, J.L. SEHGAL, H.S. SHIVARAMU AND B.K. KANDPAL

*National Bureau of Soil Survey and Land Use Planning, Nagpur - 440010*

**Abstract** : *Field experiments in Khapri Watershed of Nagpur district during Kharif, 1991 and 1992 on series level indicated that Khapri-5 (Fine, montmorillonitic, hyperthermic, Typic Chromustert) was found to be the most prefcrntial soil with an average seed cotton yield of 16.72 q ha$^{-1}$ followed by Khapri - 8 (Fine, montmorillonitic, hyperthermic, Vertic Ustochrept) with 11.72 q ha$^{-1}$ as compared to other soil series. The parameters such as higher effective rainfall and the length of growing period (LGP) higher total plant available water capacity (PAWC), higher soil depth and fine texture in Khapri-5 were responsible for higher root-shoot and, matter production and in turn the seed cotton yield. With appropriate management practices viz., earthing-up, balanced and split application of fertilizer and intensive plant protection, cotton yield was improved in Typic Ustochrept soils (Khapri-3 (a), Khapri-4 and Khapri-7) with an average yield of upto 12.56 q ha$^{-1}$ in two years. Khapri-1 and Khapri 3(b) which were Lithic and Typic Ustorthents, respectively were observed to be very low productive even with all possible crop management due to very shallow soil depth resulted in reduced LGP and low PAWC.* (**Key Words:** *Crop management, soil series, LGP, PAWC*)

Swell-shrink soils (Black cotton soils) occupy nearly 54 m.ha in India (Sehgal 1986) and grouped as Vertisols, Inceptisols and Entisols depending on the soil depth ad their profile development. In these areas cotton is one of the major crops (7 m ha) and its yield varied due to soil-site characteristics. Further, crop management interacts with soil-site characters in improving the growth and yield of the crop. It is therefore essential to study the effect of crop management in different soil sub-groups on growth and yield of cotton, under field conditions.

## MATERIAL AND METHODS

A watershed in village Khapri (Barokar) in Katol taluka of Nagpur district of Maharashtra, was selected for the study. It is situated between 21°08'18" and 21°08'44" N Lat.; 78°32'26" and 78°33'28" E Long. at 580 m above MSL. The basic soil properties is reported in (Table 1). The climate is semiarid tropical. During the cropping season of kharif

1991 and 1992 the rainfall received was 693 and 440 mm in 54 and 33 rainy days, respectively. Effective rainfall of each soil series was calculated for the cotton cropping season by substracting the water surplus from the total rainfall after meeting the crop evapotranspiration and complete storage capacity of the respective soil. Crop evapotranspiration and water surplus was calculated using Thornthwaite water balance as described by Rao *et al.* (1976). The length of growing period (LGP) was calculated for each soil series following the FAO model (Higgins & Kassam 1981).

The field experiment was carried out in *kharif* 1991 and 1992 on six soil series, Khapri-1, 3(a), 3(b), 4,5,7 and 8 with two management levels (low and optimum) in split plot design replicated four time. Two seeds per hill in 90 x 90 cm spacing, were sown. Low mana- gement consisted of side dressing of 25:25:15 kg of $N:P_2O_5:K_2O$ per ha after 20 days and one top dressing with $N_{45}$ kg per ha 50 days after sowing and other practices like two hoeings, one weeding, no earthing and only essential plant protection. The optimum management received 120:60:30 kg of $N:P_2O_5:K_2O$ per ha in three splits (60:60:30 as ring placement after 20 days followed by two top dressings with 30 kg N each at 40 and 60 days after sowing), three hoeings, two weedings, one earthing and adequate plant protection measures.

The growth attributes of cotton (Cv. H-6) such as root and shoot dry matter (DM), root length and the leaf area index, leaf area duration (LAD) were studied from three random samples during different plant growth stages. The seed cotton yield was recorded. The data were statistically analysed for test of sigificance and the correlation co-efficient.

## RESULTS AND DISCUSSION

*Effect of soil-site characteristics on cotton* : There was a significant differences in growth and yield of cotton during both the years. Khapri-5 (Typic Chromustert) was found to be the best soil with an yield potential of 14.15 and 19.30 q $ha^{-1}$ in first and second years, respectively followed by Khapri-8 (Vertic Ustochrepts) with 11.72 q $ha^{-1}$ in second year and Khapri-7 (Typic Ustochrept) with 9.58 and 10.18 q $ha^{-1}$ in first and second years. Low seed cotton yield was obtained in other Typic Ustoch-

TABLE 1. Soil-site characteristics and their influence on cotton yield.

| Hor-zon | Depth (cm) | Silt (%) | Clay (%) | O.C (%) | CaC0₃ (%) | Total PAWC (mm) | Max. root length (cm) | | LAD (days) | | Maturity duration (days) | | Seed cotton yield (q/ha) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1991 | 1992 | 1991 | 1992 | 1991 | 1992 | 1991 | 1992 |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | | (9) | | (10) | | (11) | |
| **ENTISOLS** | | | | | | | | | | | | | | |
| *Khapri -1, Loamy, mixed, hyperthermic family of Lithic Ustorthent (upper plain)* | | | | | | | | | | | | | | |
| Ap | 0-17 | 14.8 | 59.8 | 0.56 | 6.0 | 24 | 20.2 | - | 127 | - | 167 | - | 5.07 | - |
| Cr | 17-33 | - | - | - | - | | | | | | | | | |
| *Khapri -3(b), Loamy, mixed, (calcareous) hyperthermic family of Typic Ustorthent (upper plain)* | | | | | | | | | | | | | | |
| Ap | 0-15 | 13.5 | 31.3 | 0.58 | 9.1 | 66 | 17.1 | 20.6 | 119 | 88 | 168 | 171 | 4.19 | 3.38 |
| Cr | 15-50 | 15.3 | 27.2 | 0.34 | 9.8 | | | | | | | | | |
| **INCEPTISOLS** | | | | | | | | | | | | | | |
| *Khapri -3(a), Fine-loamy, mixed (calcareous) hyperthermic family of Typic Ustochrept (upper plain)* | | | | | | | | | | | | | | |
| Ap | 0-18 | 22.0 | 36.0 | 0.53 | 9.7 | 128 | 29.0 | 28.2 | 143 | 112 | 178 | 185 | 8.47 | 6.89 |
| B1 | 18-39 | 22.5 | 39.5 | 0.43 | 29.9 | | | | | | | | | |
| B2k | 39-50 | 19.6 | 29.5 | 0.35 | 32.0 | | | | | | | | | |
| Crk | 50-120 | | - | - | - | - | | | | | | | | |
| *Khapri -4, Clayey, montmorillonitic (calcareous) hyperthermic family of Typic Ustochrept (Upper plain)* | | | | | | | | | | | | | | |
| Ap | 0-15 | 13.8 | 63.4 | 0.58 | 6.1 | 86 | 25.6 | 26.9 | 128 | 121 | 176 | 182 | 8.25 | 7.30 |
| B | 15-34 | 27.4 | 42.3 | 0.44 | 7.1 | | | | | | | | | |
| Cr | 34-80 | 19.4 | 38.9 | 0.24 | 7.4 | | | | | | | | | |
| *Khapri -7, Clayey, montmorillonitic (calcareous) hyperthermic family of Typic Ustochrept (Lower plain)* | | | | | | | | | | | | | | |
| Ap | 0-15 | 13.7 | 52.1 | 1.13 | 9.2 | 80 | 27.4 | 28.6 | 153 | 151 | 180 | 199 | 9.58 | 10.18 |
| B1 | 15-23 | 25.2 | 43.3 | 0.81 | 6.9 | | | | | | | | | |
| B2 | 23-45 | 18.5 | 46.5 | 0.89 | 5.3 | | | | | | | | | |
| Cr | 45-75 | - | - | - | - | | | | | | | | | |
| *Khapri -8, Fine, montmorillonitic, hyperthermic family of Vertic Ustochrept (Lower plain)* | | | | | | | | | | | | | | |
| Ap | 0-14 | 30.9 | 56.2 | 1.05 | 0.9 | 90 | - | 32.4 | - | 165 | - | 202 | - | 11.72 |
| B2 | 14-29 | 26.5 | 60.2 | 0.89 | 1.3 | | | | | | | | | |
| B3k | 29-51 | 20.0 | 48.2 | 0.62 | 16.2 | | | | | | | | | |
| Crk | 51-66 | - | - | - | | | | | | | | | | |

| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | | (9) | | (10) | | (11) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **VERTISOLS** | | | | | | | | | | | | | | |
| *Khapri-5, Fine, montmorillonitic hyperthermic family of Typic Chromustert (Lower plain)* | | | | | | | | | | | | | | |
| A11 | 0-11 | 17.7 | 59.2 | 1.01 | 4.7 | 218 | 35.9 | 38.0 | 213 | 313 | 209 | 225 | 14.15 | 19.30 |
| A12 | 11-30 | 11.6 | 74.8 | 0.79 | 5.1 | | | | | | | | | |
| A13 | 30-56 | 12.1 | 71.8 | 0.75 | 5.3 | | | | | | | | | |
| A14 | 56-90 | 7.8 | 75.3 | 0.35 | 5.3 | | | | | | | | | |
| AC | 90-108 | 6.2 | 43.3 | 0.30 | 8.3 | | | | | | | | | |
| Cr | 108-120 | + | - | - | - | | | | | | | | | |
| SEm + | | | | | | | 1.1 | 1.3 | 10 | 4 | 2 | 1 | 0.46 | 0.64 |
| CD (0.05 p) | | | | | | | | 3.4 | 3.9 | 29 | 13 | 5 | 4 | 1.40 |

series (7.30 to 8.25 q $ha^{-1}$ in Khapri-4 and 6.89 to 8.47 q $ha^{-1}$ in Khapri-3(a) followed by still less in Khapri-3 (b) (Typic Ustorthent, 3.38 to 4.19 q $ha^{-1}$) and Khapri-1 (Lithic Ustorthent, 5.07 q $ha^{-1}$). The similar trend was also observed in root and shoot dry matter (Fig. 1) and root length (Table 1). The maturity duration of the crop is highly correlated with seed cotton yield (r=0.946) through increasing the number of pickings, varied from 167 days in Khapri-1 to a maximum of 225 days in Khapri-5. The primary factor responsible for such differences in growth, duration and yield was moisture storage capacity in the solumn of each soil. Khapri-5 had about 218 mm of total PAWC followed by 90 mm in Khapri-8, 80 to 128 mm in different series of Typic Ustochrepts and still less in Typic and Lithic Ustorthents series (66.0 and 24 mm). The correlation and regression analysis between seed cotton yield and total PAWC showed a direct highly significant correlation (Fig.2). Further, the soil depth and texture were observed to be the major characteristics for variations in total PAWC with deeper the soil and finer the texture increases the capacity of soil water retention. Khapri-5 and 8 being found on lower plain of the watershed, were deeper with higher clay and organic carbon contents. Cotton has strong lateral and deep rooting pattern and long growing period and thus the positive effect of soil depth was obvious for root development and crop duration. Pundarikakshudu *et al.* (1992) also showed the greater

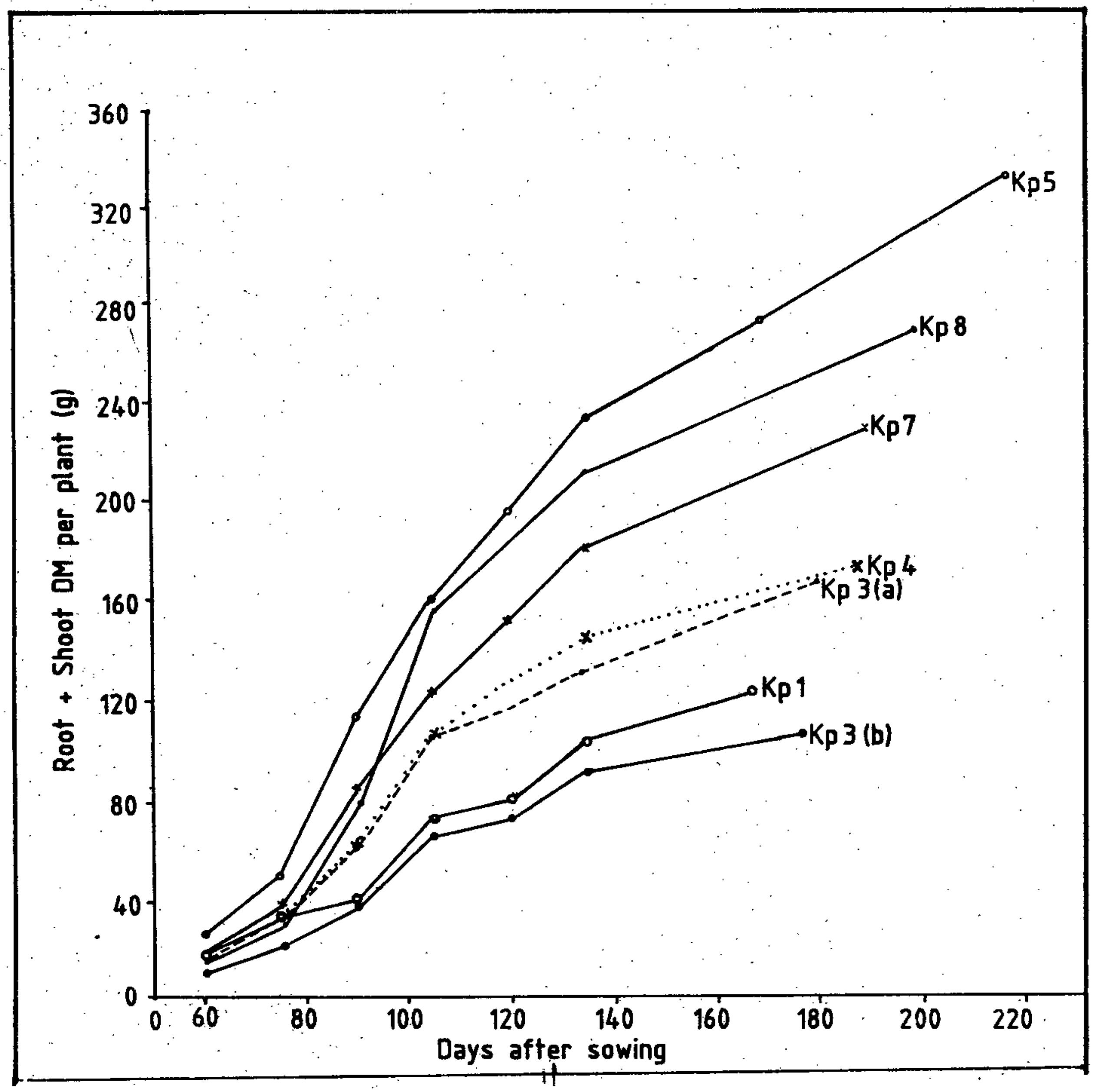


Fig. 1. Root plus shoot dry matter per cotton plant in different soils (mean 1991-92)

moisture retention and higher seed cotton yield in deep soil as compared to medium deep and shallow soil. The beneficial effect of increasing clay content was not only the increased water holding capacity but also increased the CEC and nutrient supply. Gajbhiye *et al.* (1988)

reported significant positive correlation between clay content and moisture holding capacity of the soil.

The total PAWC of soil directly influenced the effective rainfall and LGP although the total rainfall during a cropping season was same on all the soil series. Khapri-1 having a lowest PAWC of 24 mm, the effective rainfall and LGP were 303 mm and 133 days in first season and 284 mm and 125 days, respectively in second season. Whereas, Khapri-5 having 218 mm of total PAWC could conserve the entire rainfall of 440 mm in first season and 497 out of 693 mm in the second season, thereby the LGP was increased to 207 and 196 days in two years. Thus, the effective rainfall and LGP of different soils in turn had positive influences on seed cotton yield with a significant correlation coefficients of 0.717 and 0.646, respectively (Fig. 3).

Among the three soil series coming under Typic Ustochrept (Table 1), the seed cotton yields were statistically at par in first year, although the mild adverse effect of increased lime content could be observed. Whereas, in second year it was very prominent and statistically significant. The highly calcareous Khapri-3(a) gave very poor seed cotton yield (6.9 q $ha^{-1}$) although it had higher total PAWC (128 mm), effective rainfall (388 mm) and LGP (161 days) when compared to the relatively low calcaroeus Khapri-7 (10.18 q $ha^{-1}$ of yield and 80 mm, 340 mm and 127 days, respectively). Increased $CaC0_3$ content beyond 20 per cent in the form of lime nodules in the rhizophere was reported to have an adverse effect on yield of cotton (Sehgal 1991). Further, Khapri-7 series was comparatively more fertile due to its occurrence on the lower plain having more of organic carbon and clay content when compared to Khapri-3(a) (Table 1).

*Effect of management on cotton* : Although Typic Ustochrept gave comparatively low yield, but under appropriate crop management, the yield response was remarkable (Table 2). During first year on Khapri-7, the response to better management was almost 2.5 times followed by 2.2 times on Khapri-4 and 1.7 times in Khapri-3(b), whereas it was only 1.3 times in Khapri-5. The same trend of yield response to management was observed in second year also although differences, were statistically nonsignificant.

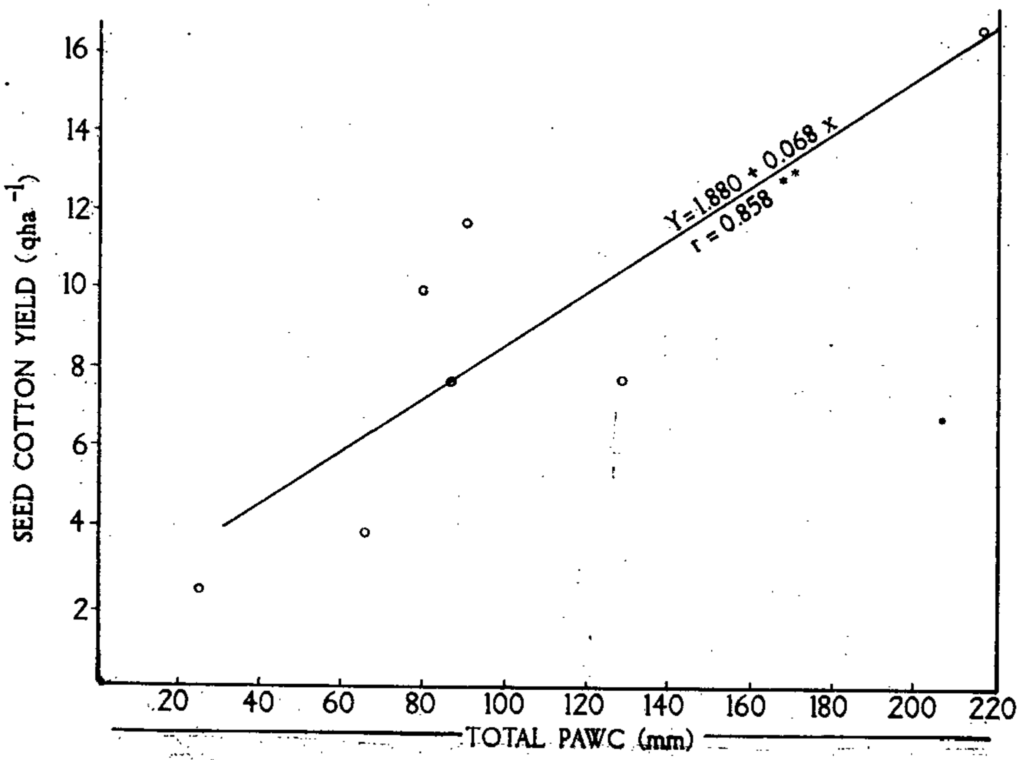


Fig. 2. Relationship between total PAWC and seed cotton yield

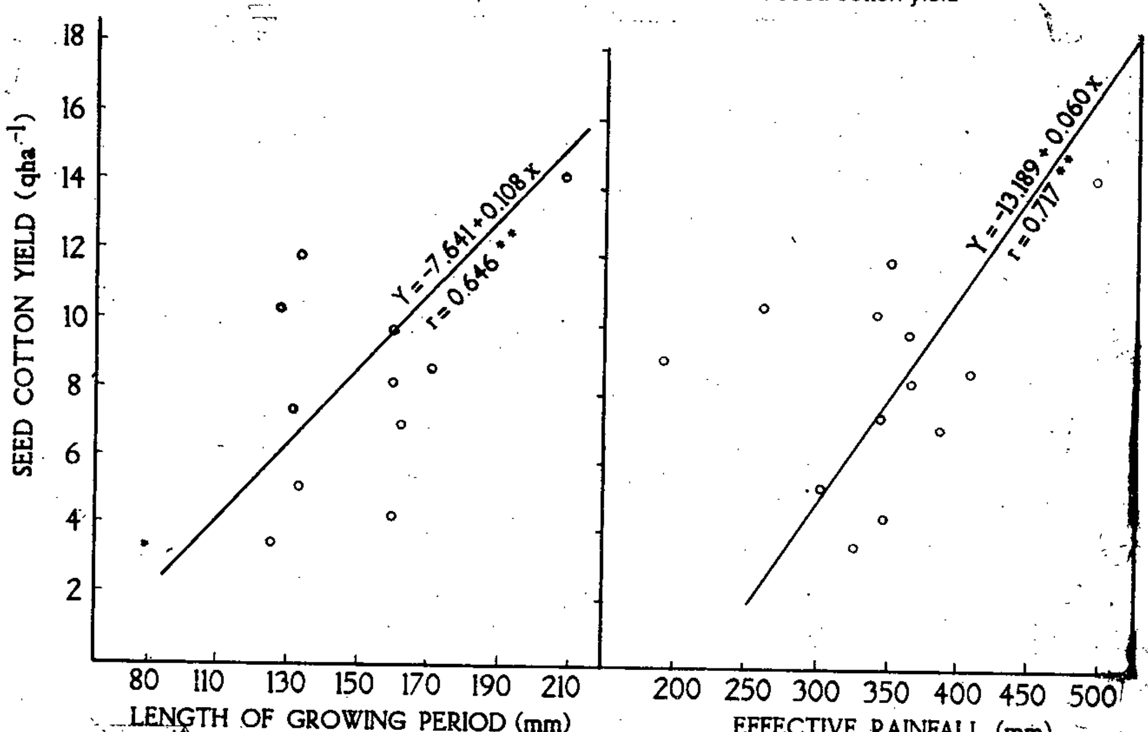


Fig. 3. Effect of length of Growing period and effective rainfall on Cotton yield

TABLE 2. Growth and yield of cotton as influenced by the crop management in different soils

| Management | Max.root length (cm) | | LAD (days) | | Maturity duration (days) | | Seed cotton yield (q/ha) | |
|---|---|---|---|---|---|---|---|---|
| | 1991 | 1992 | 1991 | 1992 | 1991 | 1992 | 1991 | 1992 |
| **Khapri-1** | | | | | | | | |
| Low | 18.0 | - | 119 | - | 165 | - | 3.82 | - |
| Optimum | 22.5 | - | 137 | - | 170 | - | 6.32 | |
| **Khapri-3(b)** | | | | | | | | |
| Low | 15.5 | 19.5 | 112 | 71 | 164 | 164 | 3.24 | 2.87 |
| Optimum | 18.7 | 21.7 | 126 | 105 | 172 | 177 | 5.15 | 3.89 |
| **Khapri-3(a)** | | | | | | | | |
| Low | 29.7 | 27.0 | 130 | 98 | 172 | 179 | 6.36 | 5.63 |
| Optimum | 30.0 | 29.5 | 155 | 126 | 184 | 192 | 10.58 | 8.14 |
| **Khapri-4** | | | | | | | | |
| Low | 23.0 | 25.7 | 114 | 107 | 168 | 176 | 5.09 | 5.50 |
| Optimum | 28.2 | 28.0 | 143 | 135 | 185 | 188 | 11.41 | 9.10 |
| **Khapri-7** | | | | | | | | |
| Low | 25.7 | 26.2 | 118 | 138 | 167 | 198 | 5.46 | 8.94 |
| Optimum | 29.0 | 31.0 | 190 | 166 | 193 | 200 | 13.71 | 11.42 |
| **Khapri-8** | | | | | | | | |
| Low | - | 30.5 | - | 150 | - | 201 | - | 10.30 |
| Optimum | - | 34.2 | - | 180 | - | 202 | - | 13.14 |
| **Khapri-5** | | | | | | | | |
| Low | 33.7 | 34.2 | 199 | 268 | 209 | 222 | 12.42 | 16.92 |
| Optimum | 38.0 | 41.7 | 228 | 358 | 209 | 227 | 15.88 | 21.68 |
| SEm ± | 2.1 | 2.7 | 12 | 7 | 3 | 2 | 0.55 | 0.61 |
| CD (0.05P) | NS | NS | 37 | 22 | 9 | 6 | 1.64 | NS |
| Mean of Low Management | 24.3 | 27.2 | 132 | 139 | 174 | 190 | 6.06 | 8.36 |
| Mean of Optimum Management | 27.7 | 31.0 | 163 | 178 | 185 | 198 | 10.51 | 11.23 |
| SEm ± | 0.9 | 1.1 | 5 | 3 | 1 | 1 | 0.2 | 0.25 |
| CD (0.05 P) | 2.6 | 3.3 | 15 | 9 | 4 | 2 | 0.67 | 0.74 |

Optimum management characterized by earthing of individual hill of cotton plants at the last top dressing stage and balanced supply of NPK fertilizer with three splits of nitrogen were among other management practices when compared to low management. Earthing up might have overcome the constraint of soil depth to some extent in Typic Ustochrepts associated with minimizing the effect of calcareousness through more of root development in Ap horizon. Further balanced and split application of fertilizers made timely availability of NPK nutrients to cotton plants. Thus, the effect of management was more in Typic Ustochrept as compared to Typic Chromustert.

In Khapri-1 and 3 (b), the response to optimum management on seed cotton yield was more (1.59 to 1.65 times of low management) than that in Khapri-5 (1.3 times of low management). However, the crucial factor in Khapri-1 and 3(b) was soil depth which was very less (15 to 17 cm) and hence the potential yield was only around 5 q per ha even with all possible crop management. Similarly, the crop maturity duration and the leaf area duration in Typic Ustochrept series were increased more than those in other series due to optimum management thus supporting the trend of seed cotton yields.

The optimum crop management in general, irrespective of the soils, significantly increased the seed cotton yield from 6.1 to 10.5 q $ha^{-1}$ in first year and from 8.4 to 11.2 q $ha^{-1}$ in second year and so also the maximum root length, leaf area duration and maturity of the crop. Thus, Khapri-5 (Typic Chromustert) is the most preferential soil for cotton followed by Khapri-8 (Vertic Ustochrept). With appropriate management practices, Khapri-3(a), 4 and 7 (Typic Us tochrepts) were also found to be productive. Hence, it is the crop management in appropriation to the land resources help in improving the growth, duration and yield of cotton.

## REFERENCES

Gajbhiye, K.S., Deshmukh, S.N., Gaikawad, M.S. & Vaidya, G.S. (1988) Studies on moisture characteristic curve and crop response in Vertisols. Tran. Intl. workshop on swell-shrink soils, 24-28 Oct. 1988, National Bureau of Soil Survey and Land Use Planning, Nagpur.

Higgins, G.M. & Kassam, A.H. (1981) The FAO agro-ecological zone approach to determination of land potential. *Pedologie, XXXI* (2): 147-168.

Pundarikakshudu, R., Mudholkar, N.J. & Wankhede, N.P. (1992) Effect of comparative efficiency of planting methods and soil depth on rainfed cotton *(Gossypium hirsutum)* in Vertisols. *Indian J. Agril. Sci.,* **62***(4)* : 263-7.

Rao, K.N., George, C.J. & Ramasastri, K.S. (1976). *The climate water balance of India.* Vol. XXXII, Part III. Memories of the Indian Meteorological Dept. Controller of Pub. Delhi.

Sehgal, J.L. (1986) Introductory pedology *(Soil genesis, Survey and Classification)*. Kalyani publishers, New Delhi.

Sehgal, J.L. (1991) Soil-site suitability evaluation for cotton. *Agropedology,* **1** : 49-64.