CHAPTER VI
6. SUMMARY

For nutritional studies, the chromite overburdens were brought from Kaliapani mine sites of Sukinda block in Cuttack. This was air dried and screened through 2 mm sieve and packed in 10 lt. capacity earthen pots for conducting different studies. Seven pot culture experiments were conducted in chromite overburden from 1986-89 with fertilisers and soil amendments like lime (CaCO₃) and organic manures taking Palmarosa, Jamrosa, C. pendulus and C. flexuosus as the test crops at Regional Research Laboratory, Bhubaneswar. First and second pot culture experiments were conducted to study the effect of levels of Nitrogen fertilisers with a fixed dose of P₂O₅ and K₂O on different biometric observations of Palmarosa species. The effects of levels of N fertilisers in combination with FYM was also studied in this overburdens.

The third pot culture experiment was also conducted with Palmarosa species to compare the overburden soil alone and in combination with different proportions of farm yard manure with lateritic soil
at recommended doses of fertilisers. The fourth pot culture experiment was also carried out to compare the growth performance of five aromatic species such as Palmarosa, Jamrosa, *C. winterianus*, *C. pendulus* and *C. flexuosus* in chromite overburden with respect to their plant height, tiller number, chlorophyll content, oil content and herb yield at a recommended dose of fertilisers. The fifth and sixth pot culture experiments were conducted to study the response of four aromatic species such as Palmarosa, Jamrosa, *C. pendulus* and *C. flexuosus* to fertiliser doses and lime levels in chromite overburden. The seventh pot culture experiment was also conducted to study the effect of lime alone and in combination with organic matter sources on Jamrosa, its plant height, tiller number, chlorophyll content, oil and herb yields in chromite overburden. These pot culture experiments were conducted throughout the year at variable climatic conditions at Regional Research Laboratory, Bhubaneswar.

The various results obtained as summarised below

* The application of 90 kg N/ha along with 40 kg P_2O_5 and 40 kg K_2O/ha was found to be the suitable recommended dose for Palmarosa species in chromite overburden. This dose can increase
the yield of herbs, plant height, tiller numbers significantly over other nitrogen levels and control.

If organic manures like FYM is available and farmers can afford to apply it, this can be done at the rate of 10t/ha in the overburden to create a favourable soil environment for aromatic and medicinal plants.

Based on their performance with regard to plant height, tiller numbers, herb yield of aromatic plant species, viz., Palmarosa, Jamrosa, C. winterianus, C. pendulus and C. flexuosus, the species Palmarosa and Jamrosa are found to be the best species to be grown in overburden. Further the species Jamrosa was judged to be the most economic and profitable species recommended for chromite overburdens.

A dose of 100 kg N, 50 kg P₂O₅ and 50 kg K₂O was found to be the most economic recommended dose for getting three consecutive harvests of aromatic species in chromite overburden in boosting the herb and oil yield. These fertilisers are to be applied in three equal proportions to each growth period (for three consecutive harvests). One third of P₂O₅
and $K_2O$ and 25% N was to be applied at the
time of planting the slips and the rest N%
(75%) was to be applied in splits - 50% at
20 days of planting and 25% at 45 days of
planting to maximise the herb yield.

The effect of fertiliser doses and lime ($CaCO_3$)
levels on Palmarosa Jamrosa, C. *pendulus* and
C. *flexuosus* was also being assessed on the
performance of their biometric observations.
The addition of fertilisers and lime ($CaCO_3$)
in overburden was brought about the highest
plant height and chlorophyll content in
Palmarosa species than Jamrosa, C. *pendulus*
and C. *flexuosus* whereas the Jamrosa species
has achieved the highest tiller numbers, herb
and oil yields over Palmarosa, C. *pendulus*
and C. *flexuosus* due to addition of fertiliser
doses and lime levels. These two species,
I.e., Palmarosa and Jamrosa have well responded
to fertiliser doses than the lime levels and
are judged to be the best species for over-
burdens.

The addition of lime as $CaCO_3$ has not increased
the plant height, tiller numbers, chlorophyll
content, herb and oil yields significantly
and consistently in consecutive harvests and
years due to the very simple reason of fixing the lime requirement value (1 LR) at 6t CaCO₃ per hectare when the pH of the no-lime-control pot was increased from 0.7 to 1.0 unit due to additions of water only and maintaining the overburden at field capacity and higher than that. This has lead to the conversion of active Al³⁺, Fe³⁺ ions into insoluble forms and that of Cr VI to Cr III. This has helped in increasing the pH of the no-lime-control pot upto 1 unit thereby the application of 6t CaCO₃/hectare has not been reflected in the increase of plant height, tiller numbers, chlorophyll content, herb and oil yields as has been done by the fertiliser doses. In future a lower dose of lime, i.e., 0.25 LR (1.5 t CaCO₃/hectare) and 0.5 LR (3t CaCO₃/hectare) may be tried along with 100 kg N, 50 kg P₂O₅ and 50 kg K₂O per hectare to maximise the herb production in chromite overburdens.

The beneficial effects of lime was to nullify the toxic effects of Al, Fe and Cr from the overburden and simultaneously to increase the availability of Ca and PO₄ ions for crop uptake. Therefore, the uptake of Fe and Cr
has been reduced in lime treated pots than the lime control pots. Secondly, the uptake of N, P₂O₅, K₂O, Ca and Mg has been increased due to addition of lime as evidenced by uptake studies presented in Appendix.

The effect of lime and organic matter sources were also compared in chromite overburden on species Jamrosa. The effect of lime was found superior to organic matter sources with respect to plant height, tiller numbers, chlorophyll content, herb and oil yields of Jamrosa. The farm yard manure was judged as the best organic matter source to be applied at 10t/ha to increase the herb yields alone or in combination with lime (CaCO₃). If CaCO₃ is not available, the farm yard manure also can achieve the target to some extent.

The effect of organic matter sources has helped to increase the bacterial population and activity in the overburden thereby many essential plant nutrients have become available to aromatic species in chromite overburden and ultimately the herb yields and associated characters also has increased.

Correlation studies revealed that total oil yields of Palmarosa, Jamrosa, C. pendulus
and *C. flexuosus* has positive significant correlation with tiller numbers, herb yields in three consecutive harvests, whereas it has positive significant correlation with the plant height, chlorophyll content and oil content (%) of specific species in a harvest (Table 5.1, 1987-88). Soil pH has a non-significant correlation with oil yields of each species during 1987-88. The chlorophyll content and plant height have non-significant correlations in many cases during 1987-88 and 1988-89. Similarly, the oil yields of species Palmarosa, Jamrosa, *C. Pendulus* has significant positive correlations with herb yields in three consecutive harvests whereas it has positive significant correlations with plant height, tiller number, chlorophyll content and oil content (%) of specific species in a particular harvest during 1988-89 (Table 5.1). The oil yields of Jamrosa has a positive significant correlation with soil pH in second harvest. The chlorophyll content of Jamrosa has positive correlation with pH in first harvest while the herb yields has positive correlation in first and second harvests. It clearly indicates that tiller
numbers and herb yields can influence the oil yields very much than the other morphological characters.

The uptake of Fe and Cr by four aromatic species was correlated negatively with soil pH. The Fe and Cr uptake has failed to establish any consistent correlation with soil pH as evidenced from the Table 5.2, during 1987-88 and 1988-89. But the Fe uptake of Jamrosa was correlated significantly with soil pH in three consecutive harvests, while Cr uptake by Jamrosa species was correlated significantly with soil pH in first and second harvests.

The DTPA extractable chromium (Cr) and iron (Fe) was correlated with soil pH (Table 5.2 b) for species Palmarosa, Jamrosa, C. pendulus and C. flexuosus after their harvests during 1987-88 and 1988-89 in presence of applied lime and fertiliser doses. While the DTPA extractable chromium and iron was correlated with soil pH for species Jamrosa in presence of applied lime and organic manures. The correlation studies indicate that the DTPA extractable Fe in the lime and fertiliser applied pots of Palmarosa, Jamrosa, C. pendulus and C. flexuosus has a significant negative
correlation with soil pH with correlation coefficient values (r) of 0.770**, 0.965**, 0.907**, respectively during 1987-88 and with that of Palmarosa, Jamrosa and C. pendulus had a significant negative correlation with correlation coefficient values (r) of 0.981**, 0.932**, 0.982**, respectively during 1988-89.

So also the DTPA extractable Fe in the lime and organic matter applied pots of species, Jamrosa had a significant negative correlation with soil pH and had a 'r' value of 0.927**.

The DTPA extractable Cr in the lime and fertilizer applied pots had a negative correlation with soil pH with correlation coefficient values (r) of 0.914**, 0.706*, 0.590, 0.645 during 1987-88 and that of Palmarosa Jamrosa and C. pendulus had a significant negative correlation with soil pH with correlation coefficient values (r) of 0.911**, 0.853** and 0.69* during 1988-89, respectively. Similarly, the DTPA extractable Cr in the lime and organic matter treated pots of Jamrosa had a non-significant negative correlation with soil pH.

Lastly, due to addition of lime (CaCO₃) and organic matter sources the chromium and iron content had decreased with availability of essential plant
nutrients such as N, P, K, Ca, Mg which ultimately had increased the herb yield and oil content.

Based on the foregoing observations, the following conclusions seem appropriate:

1. On the whole, the aromatic and medicinal plants like Palmarosa, Jamrosa, C. pendulus and C. flexuosus are positively benefited by the application of fertilisers, lime and organic matter sources.

2. The beneficial effect of liming is due to precipitation of soluble aluminium, chromium and iron, solubilisation of native phosphate and possibly on increased availability of added soluble sources of phosphates.

3. As the application of lime (CaCO₃) at the rate of 6t/ha (1 LR) has become high for chromite overburdens (determined by Woodruff's buffer method) a desirable dose of lime possibly a lower dose (0.25 LR or 0.50 LR) may be tried before sowing aromatic species to get maximum benefit. If lime is not available, application of FYM @10t/ha or plant stubbles @ 1t/ha will solve the problems.
4. A fertiliser dose of 100 kg N, 50 kg $P_2O_5$ and 50 kg $K_2O$ may be recommended for chromite overburdens to maximise herb/oil yields of aromatic and medicinal plants in three consecutive harvests.

5. Palmarosa and Jamrosa species are judged to be the best species to be recommended for chromite overburdens for higher herb and oil yields.

6. Further research is warranted to evaluate quantitative estimation of heavy metals in the wild grown species and induction of varieties for selection of ideal plant type for heavy metal tolerance in chromite mined overburdens.

7. As this is one of the first systematic works on evaluation of economic (aromatic and medicinal) plants with lime, fertiliser and organic matter amendments in chromite overburdens, this study has failed to achieve the other objectives such as evaluation of drought resistance species, assessment of water requirement of these species, and floristic studies of wild grown species.