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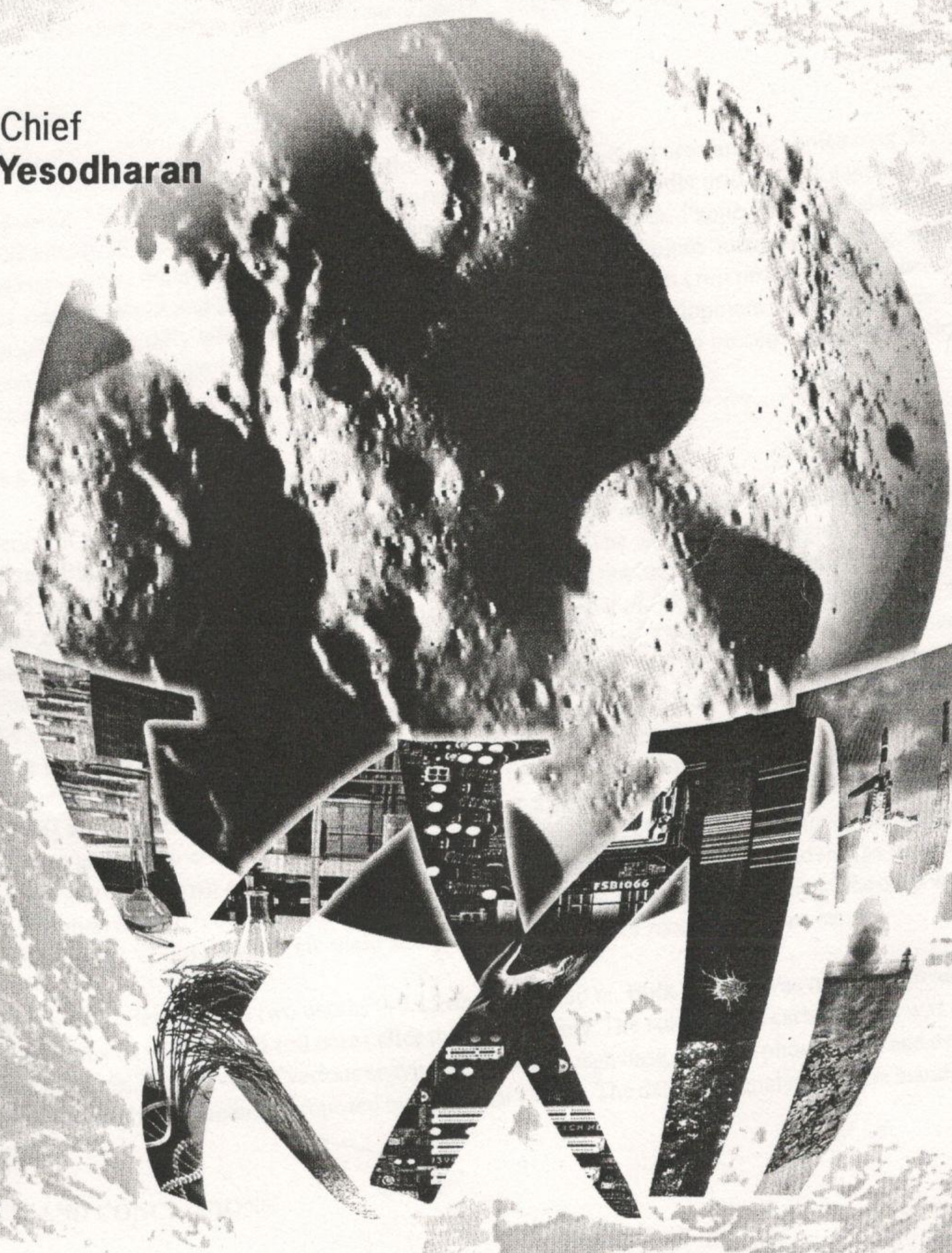

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Integration of tillage and soil amendments for improving the productivity and biological properties of shallow hard pan soils of Arid Gujarat

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INTRODUCTION

The arid zone of India covers about 12 per cent of the country's geographical area and occupies over 31.7 m ha of hot desert and about 7 m ha under cold desert. In Gujarat, 6.22 m ha area is under arid zone. Kachchh is the largest district (45,652 km sq) in the state of Gujarat and the entire region is under arid zone. Soil related constraints like low organic matter status, inherently low soil fertility in terms of macro and micro nutrients, crusting, and presence of hard pan at variable depth and shallow soil depths, pose severe limitation to crop production in this region. The compact subsurface especially with shallow soils does not allow proper development of root systems in several crops and leads to decline in the yield. (Devi Dayal *et al.*, 2009). Therefore, the present study was undertaken to find out the management options for improving soil productivity in this region.

MATERIALS AND METHODS

A field experiment was carried out at the research farm of Central Arid Zone Research Institute, Regional Research Station, Kukma, Bhuj, Gujarat during rainy (*kharif*) season of 2009. The climate of the region is arid with average rainfall of 315.3 mm (average of last 15 years). The soil is alkaline in reaction (pH 8.3), non saline (EC 0.3 dSm^{-1}), low in organic carbon (0.43 per cent), available N (100.4 kg ha^{-1}) and P (6.0 kg ha^{-1}) and medium in K (45 kg ha^{-1}). The land selected for experiment was under perennial grasses for the last 15 years. The field experiment was laid out with four tillage practices (Deep: tillage to 0.25 to 0.30 m depth with a tractor drawn mold board plough, followed by one pass of cultivator and harrow, Shallow: tillage to 0.12-0.15 m depth by tractor drawn cultivator passing twice followed by leveling with harrow, Minimum: by one time surface passing of cultivator and Control: with direct seeding) as main treatments and were split into four soil amendments (gypsum at 5 Mg ha^{-1}, farm yard manure (FYM) at 5 Mg ha^{-1} and both gypsum and FYM at 5 Mg ha^{-1} each and control) as sub treatments. The experiment was laid out in a split plot design with three replications. Clusterbean (*Cyamopsis tetragonoloba* L. Taub) cv *Maru guar* was sown on 18th July 2009. All the agronomic practices were followed as recommended for the region. The total rainfall received during the crop periods was 432.2 mm in 6 rainy days. The crop was harvested on 24th October 2009. Grain yield, straw yield and yield attributes were recorded at harvest.

Soil samples were collected from two depths 0-0.15 and 0.15-0.30 m. Bulk density was measured from 0-0.15 and 0.15-0.30 m depths on undisturbed soil cores after the crop harvest. The soil organic carbon stock was computed as per standard methods. The activity of various enzymes viz. acid phosphatase, alkaline phosphatase and dehydrogenase in soils were assayed by the methods proposed by Tabatabai (1982). The data were analysed as per standard statistical procedures.

RESULTS AND CONCLUSIONS

Yield and yield attributes

Tillage practice significantly influenced the yield attributes, grain and straw yields of clusterbean. The deep tillage increased the grain yield by 170.6 per cent over control (123 kg ha^{-1}), 56.8 per cent over minimum tillage and 18.5

per cent over shallow tillage. However the yields obtained under deep and shallow tillage were statistically at par. The trend in straw yield was also similar to that of grain yield in all the tillage treatments. The increase in straw yield under deep tillage over control, minimum tillage and shallow tillage was 77.9, 54.5 and 32.4 per cent, respectively. The higher grain and straw yields in deep tillage as compared to other tillage practices could be attributed to better soil physical environment provided by the deep tillage.

Application of gypsum along with farm yard manure (at 5 t ha^{-1} each) resulted in significantly higher grain yield of 277 kg ha^{-1} over the application of FYM (258 kg ha^{-1}) and gypsum (219 kg ha^{-1}) alone and control (199 kg ha^{-1}). Combined application of gypsum and FYM resulted in an increase of 41.4 per cent in straw yield over control, 24.3 per cent increase in straw yield over application of gypsum at 5 t ha^{-1} and 17.8 per cent over application of FYM. The increased yields with application of gypsum and FYM were attributed to improved soil properties and water and nutrient availability.

Soil quality

The tillage practices altered the bulk density properties of the soils. At harvest, the bulk density in deep tillage was 1.36 Mg m^{-3} in the surface and 1.39 Mg m^{-3} in the sub surface. There was a reduction of in bulk density of 7. 4 per cent and 9.3 per cent respectively at surface and sub surface layers in deep tillage over control. The soil organic carbon in the soil after harvest of the crop was found to be significantly higher in control plots than the rest of treatments, at both surface (0 – 0.15 m) and subsurface layers (0.15-0.30 m). Surface layers recorded higher organic carbon status than sub surface layers in all the tillage treatments, except deep tillage. Different tillage practices significantly altered the soil organic carbon stock. At harvest the soil organic carbon stock in the surface layers were higher by 59.4 per cent in control plots, 52.6 per cent in minimum tillage and 32.4 per cent in shallow tillage and over deep tillage practices. The same trend was observed in sub surface layers also. Shallow tillage plots recorded 32.4 per cent more carbon stock than deep tillage.

The application of soil amendments increased the soil organic carbon, but the results were non significant. Control plots registered higher bulk density (1.44 Mg m^{-3} surface and 1.50 Mg m^{-3} sub surface) compared to treatment receiving both gypsum and FYM at 5 Mg ha^{-1}. (1.38 and 1.42 Mg m^{-3}). The effect of various soil amendments on organic carbon, bulk density and soil organic carbon stock were non significant. The tillage practices significantly lowered the enzyme activities in soil. At harvest the activity of dehydrogenase enzyme was significantly higher in control plots that were on par with minimum tillage. Deep tillage reduced dehydrogenase by 54 per cent and shallow tillage by 17 per cent over the control. The activity of alkaline phosphatase was greater in control plots by 94.8 per cent, over deep tillage and by 69.3 per cent, over shallow tillage. The surface layers exhibited higher enzymatic activity in all the tillage treatments except deep tillage. Tillage did not influence the acid phosphatase activities. Application of amendments improved the soil enzymes, but the effect was statistically not significant.

The shallow hard pan soils in the arid regions can be better managed for higher productivity by adopting shallow tillage practices along with the application of farm yard manure and gypsum. Although the highest grain yield (339 kg ha^{-1}) was obtained under deep tillage, with combined application of gypsum and FYM, it was statistically on par with shallow tillage along with application of gypsum and FYM. The shallow tillage practices were also helpful for conserving a carbon stock of 32.4 per cent over deep cultivation. Under shallow tillage, the reduction in soil enzymatic activities was also less in comparison to deep tillage.

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