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# Influence of Various Cropping Systems on Composition of Surface Runoff

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**Abstract:** Field experiment was undertaken at Agronomy Farm, Gujarat Agricultural University, Anand Campus, Anand, during 1992-93 and 1993-94, to study the effect of various cropping systems on composition of surface runoff water and eroded sediments using runoff plots, with ten treatments consisting of sole crop of pearl millet (PM), pigeonpea (PP), bidi-tobacco (BT) and groundnut (GN) and their intercropping systems (PM+GN, PP+GN, BT+GN and PM+PP), including cultivated (CF) and absolute fallow (AF) treatments. The content of various nutrients (N, P, K) in runoff water and sediment fractions was the highest under sole groundnut crop. Groundnut as intercrop with bidi-tobacco and pigeonpea crops increased the content of various nutrients in runoff water and in sediment fractions in comparison to that in respective sole crops. Among various cropping systems, sediment density under sole groundnut plot was significantly lower (2572 mg $L^{-1}$) than in the rest of the cropping systems. A significant reduction in sediment density was observed when groundnut crop was taken as intercrop with bidi-tobacco and pigeonpea crops, than that under their respective sole crops.

**Key words:** Surface runoff, nutrient content, sediment density.

Considerable attention has been given to erosion losses in terms of kilograms or hectare metre of runoff water. Less attention has been given to the composition of runoff water and eroded sediment. Erosion being a selective process, eroded sediments are usually enriched in organic carbon (OC) and nutrient contents when compared to the soils from which they were derived (Sharpley, 1985). Beke *et al.* (1989) reported that the surface canopy influences the composition of runoff water and eroded sediments. In view of this, the present study was undertaken to evaluate the effect of various cropping systems on composition of surface runoff water.

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## Materials and Methods

A field experiment was carried out for a period of two years (1992 to 1994) at Gujarat Agricultural University, Anand, in 25.2 m long and 2.4 m wide runoff plots, having a mean slope of 0.75%, with collection tanks (350 L capacity). The soil is loamy sand in texture (Typic Ustifluents), with pH 7.7, EC 0.11 dS $m^{-1}$, OC 1.52 g $kg^{-1}$, total N 0.35 g $kg^{-1}$, P 1.31 g $kg^{-1}$ and K 12.8 g $kg^{-1}$. There were ten treatments, consisting of sole crop of pearl millet (PM), pigeonpea (PP), bidi-tobacco (BT) and groundnut (GN) and their intercropping systems (PM+GN, PP+GN, BT+GN and PM+PP), including cultivated (CF) and absolute fallow (AF) treatments.

From each rainfall event, the volume of runoff collected in each of the tank

*Table 1. Average nutrient content in sediment fractions of runoff water under different cropping systems*

| Cropping systems | OC (g kg$^{-1}$) | Nitrogen (g kg$^{-1}$) | Phosphorus (g kg$^{-1}$) | Potassium (g kg$^{-1}$) | Average soil loss t ha$^{-1}$ |
|---|---|---|---|---|---|
| CE | 3.93 (2.47)* | 0.424 (1.21) | 1.50 (1.15) | 13.4 (1.04) | 8.47 |
| AF | 6.22 (4.09) | 0.615 (1.75) | 1.61 (1.22) | 14.1 (1.10) | 0.73 |
| SPM | 6.85 (4.40) | 0.515 (1.46) | 1.65 (1.31) | 14.5 (1.14) | 2.52 |
| SPP | 5.12 (3.37) | 0.499 (1.41) | 1.78 (1.36) | 13.9 (1.08) | 6.14 |
| SBT | 4.05 (2.66) | 0.467 (1.32) | 1.63 (1.24) | 13.8 (1.08) | 7.44 |
| SGN | 7.69 (5.05) | 0.697 (1.98) | 2.26 (1.32) | 17.3 (1.35) | 2.01 |
| PM+GN | 7.13 (4.69) | 0.589 (1.67) | 1.96 (1.49) | 15.3 (1.20) | 3.04 |
| PP+GN | 6.48 (4.27) | 0.605 (1.72) | 2.09 (1.59) | 16.5 (1.29) | 3.52 |
| BT+GN | 6.00 (3.94) | 0.637 (1.81) | 1.97 (1.50) | 16.2 (1.26) | 4.07 |
| PM+PP | 6.27 (4.13) | 0.538 (1.53) | 1.86 (1.42) | 14.9 (1.17) | 3.47 |
| CD (0.05) | 1.31 | 0.061 | 0.23 | 0.8 | 1.36 |

*Figures in parentheses indicate nutrient enrichment ratios of the sediment loss through runoff.

was measured at 8.00 a.m. After recording the volume, the contents of the tanks were thoroughly stirred and a representative sample of 5 L soil-water suspension was taken for determination of sediment density and chemical analysis. Two to three drops of toluene were added to each sample for suppressing the microbial growth. The sediment density was estimated by evaporating 250 ml of mixed runoff samples at constant temperature of 60°C and residue was weighed and results expressed in mg L$^{-1}$ (sediment density) and t ha$^{-1}$ (soil loss).

Contents of soluble nutrients (N, P, K) in runoff water and OC and total N, P and K contents in sediment fractions of runoff were determined following Jackson (1973).

During crop growth period 672.0 mm rainfall was recorded in 1992, and 774.8 mm in 1993. Of these, 367.2 and 567.4 mm rainfall induced runoff under different cropping systems during the year 1992 and 1993, respectively.

## Results and Discussion

### *Nutrients content in sediment fractions of runoff*

Organic carbon, total N, P and K contents in eroded sediments from various cropping systems ranged from 3.93 to 7.69 g kg$^{-1}$, 0.42 to 0.70 g kg$^{-1}$, 1.50 to 2.26 g kg$^{-1}$ and 13.4 to 17.3 g kg$^{-1}$, respectively, which were higher than in the soil from which they were derived (OC 1.52 g kg$^{-1}$, total N 0.35 g kg$^{-1}$, P 1.31 g kg$^{-1}$ and K 12.8 g kg$^{-1}$). These results also substantiated the values of enrichment ratios for OC, total N, P and K (Table 1). The content of OC and total N, P and K in sediment fractions of runoff differed significantly under various cropping systems. Maximum OC (7.69 g kg$^{-1}$), total N (0.70 g kg$^{-1}$), P (2.26 g kg$^{-1}$) and K (17.3 g kg$^{-1}$) in sediment fractions were observed under sole groundnut crop. Groundnut as intercrop with pigeonpea and bidi-tobacco also increased OC and other nutrients in comparison to the contents under sole crops. Thus, spreading growth habit of groundnut crop

*Table 2. Average nutrient content and sediment density in runoff water under different cropping systems*

| Cropping systems | Nutrient content (mg L$^{-1}$) | | | Sediment density (mg L$^{-1}$) | Runoff (%) |
|---|---|---|---|---|---|
| | N | P | K | | |
| CE | 0.69 | 0.54 | 1.89 | 5110 | 32.5 (152.0)* |
| AF | 1.06 | 0.62 | 2.62 | 1631 | 9.9 (46.4) |
| SPM | 0.83 | 1.12 | 2.36 | 3074 | 16.7 (78.0) |
| SPP | 0.89 | 0.71 | 2.01 | 4304 | 27.4 (128.1) |
| SBT | 0.93 | 0.58 | 1.90 | 4586 | 30.9 (144.7) |
| SGN | 1.35 | 1.44 | 2.68 | 2572 | 13.9 (64.9) |
| PM+GN | 0.92 | 1.24 | 2.51 | 3149 | 17.6 (82.4) |
| PP+GN | 1.16 | 1.23 | 2.19 | 3420 | 18.4 (86.2 |
| BT+GN | 1.14 | 1.18 | 2.22 | 3537 | 20.4 (95.4) |
| PM+PP | 0.88 | 1.14 | 2.25 | 3378 | 19.6 (91.5) |
| CD (0.05 | 0.21 | 0.35 | 0.38 | 489 | |

* Figures in parenthesis indicate nutrient enrichment ratios of the sediment loss through runoff.

reduces the kinetic energy of the runoff water, thereby decreasing the transport of heavier particles with a corresponding increase in the finer fraction. Minimum contents of OC, N, P and K were observed in sediments from cultivated fallow plot. Lower contents of nutrients were associated with higher soil loss (Table 1). Palis *et al.* (1990) also reported that the nutrient concentration of sediment depended upon the fineness of sediment, i.e., when the sediment density was low, the nutrient content was high (Table 2).

*Nutrient content in runoff water*

Among sole crops, the minimum nitrogen content (0.83 mg L$^{-1}$) was observed in runoff water obtained from pearl millet plot, which was significantly lower than that in runoff water obtained from groundnut plot (1.35 mg L$^{-1}$). This is because of more N requirement by pearl millet crop, coupled with high uptake (82.1 kg N$^{-1}$). The highest content of N in runoff water from groundnut plot was due to dense vegetative cover on the surface which provided more time for dissolution and transportation of nutrients through runoff water (Table 2).

Phosphorus content in runoff water from intercrop plots was higher (1.14 to 1.24 mg L$^{-1}$) as compared to that in runoff water from sole crops, except under groundnut (Table 2). However, potassium content in runoff water was higher from pearl millet, groundnut and their intercropping systems than that in runoff water from other cropping systems. The contents of N, P, K in runoff water has relation with the amount of runoff water. The highest mean N, P, and K contents in runoff water was found where runoff was the least. These results are also substantiated by the significantly negative correlation between runoff water (mm) and content of nitrogen (r = 0.535*), phosphorus (r = 0.479*) and potassium (r = 0.428*).

*Sediment density in runoff water*

Sediment density differed significantly under various cropping systems (Table 2). The average maximum sediment density

(5.11 g $L^{-1}$) was obtained under cultivated fallow plot as the land was directly splashed by rain drops and also because no barriers existed to the flow of runoff water. Minimum sediment density (1.63 g $L^{-1}$), which was recorded under absolute fallow plot, was due to dense vegetative cover provided by the weeds. Among various cropping systems, the sediment density under groundnut plot was significantly lower (2.57 g $L^{-1}$) than that in rest of the cropping systems. A significant reduction in sediment density was observed when groundnut was taken as an intercrop with pigeonpea and bidi-tobacco crops. This was due to spreading habit of groundnut crop which obstructed the runoff flow, resulting in decreased runoff velocity, and the sediment load in runoff water. These results were substantiated by highly significant positive correlations (r = 0.931 to 0.992) between runoff (mm) and sediment density under different cropping systems. The results are in agreement with the results reported by Kale *et al.* (1992).

It appears from the foregoing results that the nutrients content in sediment and runoff water are higher under sole crop of groundnut and the cropping systems involving groundnut as an intercrop. Though contents are higher, it does not mean that the total amount of nutrient losses through runoff are higher under these cropping systems. The vegetative cover provided by groundnut crop dissipated the rainfall energy, reduced the flow velocity of runoff water, increased the retention time for runoff water, and helped sedimentation of relatively heavier fraction. Only higher and finer fractions were carried, which ultimately resulted in higher contents under these cropping systems.

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