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Influence of NPK fertilization on biomass production of *Pennisetum pedicellatum* seeded on coal mine spoil

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Physically, nutritionally and microbiologically impoverished coalmine spoils present rigorous conditions for both plant and microbial growth (Jha & Singh 1993a). Natural process of ecosystem redevelopment including accumulation of organic matter and nutrients in these habitats is a slow process (Srivastava *et al.* 1989; Jha & Singh 1991, 1992). Building up of soil organic matter, nutrient retention and facilitation of natural invasion of native plant and animal species are the main objectives of restoration of drastically disturbed lands (Singh & Jha 1993; Singh *et al.* 1995). Early researches in the present study region indicated the possibility of establishing vegetation directly on mine spoil without the placement of top soil (Jha & Singh 1993b).

Our objectives in this study were to establish grass cover on a mine spoil rapidly through direct seeding and application of different doses of NPK fertilizer. The grass cover would serve as mulch and as a trap for wind-blown seeds and other materials. We selected *Pennisetum pedicellatum* Trin. which is a much branched leafy annual grass 30-90 cm in height.

The study was conducted at Jayant coalmine in the Northern Coalfield Limited, Singrauli. Singrauli Coalfield extends over 2200 sq. km (latitude 23°47'-24°12' N, longitude 81° 48'-82°52' E and elevation 280-519 m above mean sea level) of which 80 sq. km lies in Uttar Pradesh and the rest in Madhya Pradesh. The climate is tropical monsoonal and the year is divisible into a mild winter (November-February), a hot summer (April-June) and a warm rainy season (July-September). Mean monthly minimum temperature within an annual cycle ranges from 6.4-28°C and mean monthly maximum from 20-42°C. The annual rainfall averages 1069 mm of which about 90% occurs during the period late June to September. Rainfall is characterized by a high degree of interannual variation; for example, during the period 1980-1994, the rainfall ranged from 673 to 1450 mm yr^{-1}.

Three experimental plots (20 m x 20 m) were set up on fresh coal mine spoil in July 1995, on each of the two sites. In the less rocky spoil site, the percentage of < 2 mm particles was 25%, and water holding capacity 34%. On the other hand, in more rocky spoil site, the percentage of < 2 mm soil particles was 14% and water holding capacity 31%. At both the sites each experimental plot was divided into four subplots, each 10 m x 10 m in size. One subplot was treated with full dose of NPK (N as urea 60 kg/ha, P as single superphosphate 30 kg/ha, K as muriate of potash 40 kg/ha), another subplot with ½ dose of NPK and two subplots were maintained as control without fertilizer amendment. In each subplot five 20 cm wide and 10 cm deep furrows spaced 2 m apart were dug. First of all the fertilizer mixture was spread in furrows and *Pennisetum pedicellatum* was seeded at a rate of 7 kg ha^{-1}. The furrows were then covered with mine spoil material. The grass crop at its peak was harvested using 3 and 6, 1 m x 1 m quadrats, respectively for less rocky and more rocky spoil site in November 1995 for control, ½ dose NPK and full dose NPK treated plots. Thus 9 and 18 quadrats were sampled respectively for less rocky and more rocky sites. Shoot biomass in each quadrat was harvested at ground level, and root biomass was sampled using 25 x 25 x 30 cm monoliths, one per harvest quadrat. The monoliths were washed with a fine jet of water on 2.0 and 0.5 mm mesh screens. The shoot and root biomass was oven-dried at 80°C to constant weight. Data were subjected to Analysis of Variance, regression analysis and 't' test.

Results indicated a marked effect of NPK fertilization on dry matter yield of *P. pedicellatum* at both the sites. However, greater plant biomass occurred on the less rocky site than on the more rocky site (Table 1). Shoot weight, root weight, and total biomass differed significantly among control, ½ dose and full dose NPK treatments ($P < 0.001$). In pot culture experiment yield of *Dactylis glomerata* increased with increase in fertilizer level, and at the highest level the yield was about twenty times that of control (Richardson & Evans 1986). Linear relationship between growth and fertilizer was reported by Richardson & Evans (1986) during restoration of grasslands after magnesian limestone quarrying. In our study the response of fertilization was not linear. Shoot biomass was four times as large in ½ dose treatment but only five times as large in full dose treatment as in control. Nevertheless, the levels of shoot biomass yield of the seeded grass were similar to those of the native grassland (Pandey & Singh 1992).

In our experiment the structural characteristics of spoil played an important role in the development of plant biomass, particularly on root growth. Root biomass and root/shoot ratio were lower on the more rocky site compared to the less rocky site ($P < 0.05$), but shoot biomass was not significantly different between the two sites. Evidently relatively more assimilates were retained in the shoot in habitats less hospitable to roots. These differences may be due to differential nutrient and water holding capacities of the sites. The less rocky spoil site had a greater proportion of fine particles and higher water holding capacity. Roberts *et al.* (1988) reported lower biomass production in *Festuca arundinacea* on high silt stone spoils which they attributed to detrimental physical properties such as rockiness, low water availability and restricted rooting volume.

In this study treatment x site interaction was significant ($P < 0.05$) only for root biomass. The root biomass on less rocky site in control was 19% and 25% of that of the full dose and ½ dose treatments, respectively. On the more rocky site the corresponding values were only 14 and 20%. Thus the relative response of root system to fertilization was greater on more rocky site.

In nutrient-poor habitats plants are adapted by an increase in biomass allocation to structures that enhance nutrient absorption (Tilman 1988). In view of the nutrient foraging strategy in nutrient-poor and

Table 1. Shoot weight, root weight, total biomass and root/shoot ratios of *P. pedicellatum* in less and more rocky spoils in NPK treatment plots.

($gm^{-2} \pm 1$ SE)

Biomass	Site	Control	½ dose	Full dose
Shoot	Less rocky spoil	$^{a}115 \pm 10_{x}$	$^{a}437 \pm 7_{y}$	$^{a}566 \pm 36_{z}$
	More rocky spoil	$^{a}101 \pm 9_{x}$	$^{a}370 \pm 30_{y}$	$^{a}503 \pm 25_{z}$
Root	Less rocky spoil	$^{a}42 \pm 3_{x}$	$^{a}170 \pm 4_{y}$	$^{a}219 \pm 6_{z}$
	More rocky spoil	$^{b}21 \pm 3_{x}$	$^{b}106 \pm 4_{y}$	$^{b}150 \pm 15_{z}$
Total	Less rocky spoil	$^{a}157 \pm 12_{x}$	$^{a}607 \pm 11_{y}$	$^{a}785 \pm 41_{z}$
	More rocky spoil	$^{a}122 \pm 11_{x}$	$^{b}476 \pm 33_{y}$	$^{a}653 \pm 40_{z}$
R/S ratio	Less rocky spoil	$^{a}0.36 \pm 0.01_{x}$	$^{a}0.38 \pm 0.01_{x}$	$^{a}0.38 \pm 0.01_{x}$
	More rocky spoil	$^{b}0.20 \pm 0.02_{x}$	$^{b}0.28 \pm 0.01_{y}$	$^{b}0.28 \pm 0.02_{y}$

Values in a row with different subscript letters are significantly different ($P < 0.05$) from each other.
Values in a column within each biomass component (shoot, root, total, R/S ratio) with different superscript letters are significantly different ($P < 0.05$) for sites.

nutrient-rich habitats, we had expected a higher root/shoot ratio in control plots than in fertilizer-applied plots. In this study, however, the root/shoot ratio was not significantly affected by fertilizer application. The general accepted model that a nutrient stress should increase the root/shoot ratio was also not found applicable in forest tree species (Ingestad & Agren 1991). In this study, on each site the root weight was positively related with shoot weight (Fig. 1) and r^2 was slightly lower for the more rocky site.

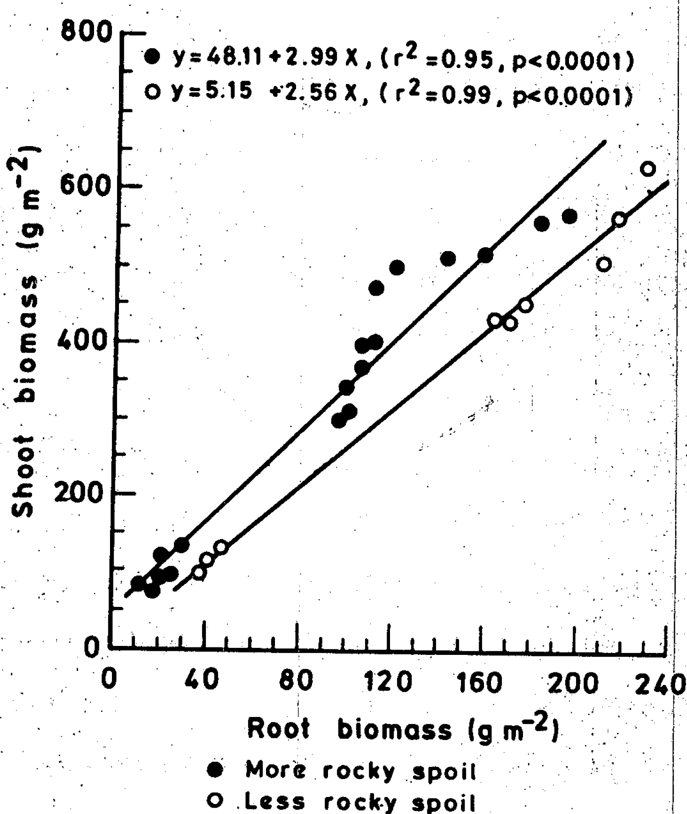

Fig.1. Relationship between shoot (Y, g m^{-2}) and root biomass (X, g m^{-2}) of *P. pedicellatum* in less and more rocky spoils.

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