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Increasing rice productivity by judicious management of watershed

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ABSTRACT

To understand the potential/ limitation of rainfed upland rice in a watershed management program through scientific management technique (SMT), a study was undertaken in Nagaria Nala watershed in Nayagarh district of Orissa. Morphometric analysis of the watershed revealed that drainage pattern is affected by structural disturbances; and watershed produces a medium peak flow for a shorter duration. Watershed was treated through various engineering structures such as water harvesting structure, percolation tank, contour bund, open well, diversion weir and loose boulder structures which enhanced soil moisture regime and life saving irrigation facilities. High yielding drought resistant short duration variety Vandana performed well through scientific management techniques in treated watersheds than untreated watershed in terms of grain yield, straw yield and net income. It is found that in treated watershed scientific management is much superior to farmer's management, both in terms of straw yield, grain yield and net income. Lowest return was obtained from farmer's management practice in untreated watershed.

Key words: *Watershed management, high yielding drought resistant variety, grain yield, straw yield, net income, scientific management technique*

The rainfed upland areas are mostly flat and unbunded. The eastern region of India comprising of Orissa, West Bengal, Bihar and parts of Madhya Pradesh are extensively cultivated for rainfed rice in upland areas where soil moisture is a limiting factor. Therefore integrated watershed management effort is essentially required to improve yield of the upland rice by tackling the soil problems related to production practices and other methods (Karale 1985). Government of India has accorded highest priority to holistic and integrated development of rainfed areas constituting about 65% of the cultivable land for meeting the projected food grains requirement estimated at 220 million tonnes by the year 2020, bridging the regional disparity in terms of production and productivity between the irrigated and rainfed areas, restoring ecological balance and generating employment opportunities for rural areas (Sahoo *et al.,* 2003). By keeping the above points in view a project was under taken for implementing the action plan prepared after detailed investigation of these areas with respect to natural and other resources on sustainable basis. In the watershed approach, the development is not confined just to agricultural lands alone but covers even the non agricultural area starting from the highest point of the area (ridge line) to outlet of the nala (valley line).

MATERIALS AND METHODS

The delineation of watershed was done by using survey of India topographical maps at 1:50,000 scale. Satellite data was interpreted following standard visual interpretation techniques. Physical and biological resources and socio-economic status of the watershed was studied by survey, data collection, identification and characterization. Prioritization of critical areas was done by detail resource inventory using GIS techniques. The methodology was developed for identification of critical areas based upon above mentioned information for prioritized land treatment in the watersheds. Action plans for both water and land resources were generated for development of watersheds with farming system approach. Integrated watershed development action plan generated through remote sensing and GIS was executed in Nagaria Nala watershed in Odagaon block of Nayagarh district of Orissa which is located geographically between $84^0$53' 17" E to 84^0 58' 0" E

longitude and 20^0', 30" N to 21^0 3' 0" N latitude having total geographical area of 1312.5 ha.

These morphometric parameters of Nagaria Nala watershed were determined from the toposheet. The parameters were number of streams of different order, bifurcation ratio, geometrical shape of basin, form factor, circulatory ratio, elongation ratio, drainage density and stream frequency. There were 53 streams of 1st order, nine streams of 2nd order and one stream of 3rd order. Stream length was 43 km and area of basin was 13 km^2. Length of basin is 4.85 km and perimeter of basin was 16.10 km. The bifurcation ratio, form factor, circulatory ratio, elongation ratio and drainage density were found to be 7.44, 0.558, 0.636, 0.843 and 3.30 respectively. The bifurcation ratio for the watershed (7.44) indicated the drainage pattern to be affected by structural disturbances suffered by the area. Form factor was high (0.558). The watershed produceed a medium peak flow for a shorter duration and flood flows could be managed by appropriate adoption of control measures (Sahoo *et al.,* 2005). The values of form factor, circulatory ratio and elongation ratio indicated that the shape of the watershed was 'fan' shaped. The drainage density for the watershed area was found to be 3.3 which was medium owing to resistant permeable rocks and medium vegetation cover.

The plan was implemented in participatory basis with watershed stake holders. The works undertaken in the watershed for raising the moisture status and increasing the irrigated area were water harvesting structure, percolation tank, contour bund, open well, diversion weir and loose boulder structures. Along with the programme, new high yielding drought resistant paddy, pulses, oilseed variety were also taken up in farmers' field. With the above development work in watershed, the present study was undertaken with the objective to evaluate performance of scientific management technique (SMT) in upland with moderately slopping landscape against the farmer's management technique (FMT) in both treated and untreated watersheds.

The experiment was conducted in randomized complete block design during 2002 and 2003 at two sites i.e. one in the treated watershed (6 villages) and the other in untreated watershed (6 villages) which were 3 km away from the treated watershed. In each village 2 farmers were associated. The topography in the northern side of the watershed was undulating and soils were shallow to moderately deep with light medium texture. The soils of the project site were acidic in reaction (pH 4.6 to 5.7) having organic carbon content 0.51 to 0.65%, available phosphorous 14.5 to 23.7 kg ha^{-1} and potassium 123.4 to 131.8 kg ha^{-1}. Rainfall during crop growth period (June to October) in the years 2002 and 2003 were 601.2 mm and 1614.5 mm respectively. The treatments were: T_1 : Farmers management technique (FMT) in treated watershed, T_2 : Farmers Management Technique (FMT) in untreated watershed, T_3 : Scientific Management Technique (SMT) in treated watershed, T_4 : Scientific Management Technique (SMT) in untreated watershed

The Scientific Management Technique (SMT) comprised of summer ploughing 3 times by improved bose plough + leveling twice by ladder, Liming in-situ @ 500 kg ha^{-1} 20 days before seeding and Line seeding by 3 row manual seed drill. Higher seed rate (100 kg ha^{-1}), along with anti termite treatment (Chlorpyriphos @ 0.75 kg ai/100 kg seed) were used, Application of farm yard manure was @ 1 t ha^{-1}. Fertilizer 40:30:20 kg NPK ha^{-1} in 3 splits were applied. Blade rake weeder was used twice. The field was irrigat water at stress period with water available in water harvesting structure (WHS) and open well.

Entire dose of phosphorous (P) after incubation with farm yard manure and potassium (K) was applied as basal in seed furrow before seeding. Nitrogen (N) in 3 splits i.e. 20 kg ha^{-1} after first weeding (20 days after seeding), 10 kg ha^{-1} at 40 days after seeding (after the second weeding) and remaining 10 kg ha^{-1} at booting stage was applied.

Farmers management technique (FMT) was comprised of ploughing and leveling the land twice by country ploug. Seeds were broadcasted @ 100 kg ha^{-1}. Farm yard manure @ 0.25 t ha^{-1} as basal and 20 kg N ha^{-1}, was applied at tillering stage. Hand weeding was done twice. As therewas no source of irrigation available leaf spraying was restored to recover the plants from apparent stress.

Plot size was 200 m^2 while each farmer's field of 400 m^2 area was considered as a replication. The sowing was done in 2nd week of June in both the treated and untreated watershed during the year 2002 and 2003. Test crop was var. *Vandana* in both the sites.

Observations on crop growth, grain yield and straw yield were recorded. Benefit cost ratio was calculated taking into account the prevailing market rate of the produce byproduct and other ancillary expenses. Data were statistically analyzed using ANOVA technique (Panse *et al.*, 1967) (Table 1).

RESULTS AND DISCUSSION

Perusal of Table 1 shows that a particular year has no significant effect either with management practices *i.e.* farmers management technique / scientific management technique or with type of watershed *i.e.* treated/ untreated. Grain yield was more (3.15 t ha^{-1}) in treated watershed with scientific management than in any other treatments.

Scientific management practice was highly significant at 1% level as far as plant height, ear bearing tiller, grain yield and straw yield were concerned. Similarly, type of watershed had also significant effect on grain yield, straw yield and crop growth parameters. Interaction of management practices with type of watershed were significantly correlated with crop parameters, grain and straw yields. High yielding drought resistant variety *Vandana* also could not perform well in untreated watershed due to scanty rainfall during 2002. Straw yield and grain yield were reduced by 25% and 20% respectively in comparison to the year 2003. In case of treated watershed despite the rainfall being less than in normal the straw yield and grain yield in 2002 did not vary much in comparison to 2003. It was only 5.5% and 0.9% less than in the normal year. When the untreated watershed with farmers management technology was compared with treated watershed with scientific management technique, the straw yield and grain yield increased by 287% and 206% respectively in the later treatment. But there was not much variation in 2002 and 2003 in case of treated watershed when scientific management practices in both the year with scanty rainfall were compared. The variation in grain yield was 1% and 3%. This was due to the reason that in the treated watershed, scanty rainfall is supplemented by life saving irrigation from water harvest structure (WHS) and open well. In treated watershed scientific management practices gave more straw yield and grain yield in comparison to farmers management practice in both the years. In untreated watershed, farmers management

Table 1. Effect of management practices and type of watershed on plant height, yield attributes, grain yield and economics of rice crop.

Treatment	Plant height (cm)			Ear bearing tiller (m^2)			Straw yield (t ha^{-1})			Grain yield (t ha^{-1})			Gross return (Rs ha^{-1})		Net return (Rs ha^{-1})		Benefit Cost ratio		Cost of cultivation (Rs ha^{-1})
	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean	2002	2003	2002	2003	2002	2003	
T1	92	98	95.0	163	170	166.5	3.61	3.81	3.710	2.20	2.22	2.210	13,116	13,286	6593	6,713	2.0	2.02	6573
T2	62	76	69.0	95	118	106.5	1.60	2.15	1.875	1.20	1.50	1.350	6,960	8,790	1087	2,917	1.18	1.49	5873
T3	110	115	112.5	235	245	240.0	5.18	5.25	5.215	3.10	3.20	3.150	18,608	19,150	609	11,151	2.32	2.39	7999
T4	76	105	90.5	131	185	158.0	1.80	2.70	2.250	1.59	1.90	1.745	9030	11,120	1731	3,821	1.23	1.52	7299
CD for treated/ untreated at P= 0.01		24.004			71.018			0.940			1.132								
CD for management		19.497			62.482			2.400			0.6671								
CD for treated X management		2.003			-11.023			0.564			-0.2721								

technique gave the lowest straw yield and grain yield (1.6 t ha^{-1} and 1.5 t ha^{-1}) Cost of cultivation had no relation with normal or scanty rainfall in both scientific management technique and farmers management technique. In both the years in scientific management technique treatment in treated watershed, benefit cost ratio was more than in farmers management technique. Similarly, in untreated watershed, benefit cost ratio was more in case of scientific management technique in comparison to farmers management technique.

In most of the watershed development programs major objective was to create water resources by utilizing surface runoff through water harvesting structures, percolation tank, open well and check dam etc. The purpose of increasing productivity and income from cultivation could not be fulfilled unless, farmers go for scientific management practices in both wet and dry seasons. It is proved that returns from treated watershed through scientific management was much superior to farmers' management.

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