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Impact of integrated approach of land, water and nutrient management practices on agricultural productivity in Malwa region of Madhya Pradesh

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Abstract
Studies were carried out during the period from 2002 to 2004 at Ringnodia micro watershed to manage land, water and nutrient resources and their impact on the productivity of water and agricultural productivity of crops grown on black clays soils. At Ringnodia micro-watershed, 22 hectares Vertisol area was delineated to study the effects of soil and water conservation measures and best bet options for increasing productivity through farmers' participatory on-farm trials. Various measures included renovation of existing water storage structures, construction of loose boulder structure, water diversion bunds, safe disposal of runoff during rainy season, planting of improved crops and cropping system, integrated nutrient management practices etc. The impact of all the considered management practices was assessed on the ground water recharge and productivity crops after 3 years of experimentation.
Studies carried out during the year 2002-03 clearly revealed the positive impact of conservation structures on runoff reduction, soil erosion control, surface water storage in storage structures, ground water recharge and productivity enhancement. Various soil and water conservation measures could be undertaken which led to appreciable reduction in soil and water loss, increased water tables in the wells and create a storage penitential to harvest 70% of the runoff. Farmers of the watershed are now convinced of using balanced nutrition particularly recommended levels of N, P_2O_5, and S at the rates of 30, 60 and 20 kg/ha respectively and boron (2 foliar application at 30 and 45 DAS) and zinc (at the rate of 25 kg $ZnSO_4$ /ha, as soil application) to soybean as these resulted in tremendous improvement in productivity and net returns over their own practice of using only 50 kg/ha di-ammonium phosphate applied as mixed with soybean seeds.

Keywords: agricultural productivity, land and water resources, malwa region, watershed

Introduction
Soybean based production systems dominate the agricultural scenario in the state of Madhya Pradesh and have appreciably improved the economic status of farmers of rainfed areas of the state. Soybean has greater tolerance to water-logging than most other crops including cereals which were grown earlier in the region, which perhaps is the single most important reason for its widespread and rapid adoption. The productivity potential of soybean is close to 2.5 t ha^{-1} in the region. Although the production of soybean is on increase due to substantial increases in area under the crop and its yield, there is still a large yield gap of about 1.3 t ha^{-1} that needs to be bridged. Soybean area in India is likely to increase to 10 m ha by 2010, a larger portion of which would be in M.P. With intensification of soybean production systems, about 20 m tones of soybean can be produced. Unfortunately, at the current level of productivity, there is appreciable underutilization of land, water, nutrients, and climatic resources. Few well-documented congruent relational data sets on water balances, nutrient turn over weather x crop development, and seed viability are available to first understand and then to tackle the problems associated with the low productivity and un-sustainability. There are a number of socio-economic and technological constraints that are responsible for low yields of soybean, resolution of which in integrated fashion can help in bridging the gap between the realizable and realized yields. This is possible through a holistic management of natural resources of soil, water, and biotic, abiotic and socio-economic constraints.
Keeping in these views the studies were carried out at Ringnodia micro watershed OF Indore (M.P.) district to manage land, water and nutrient resources and their impact on the productivity of water and agricultural productivity of crops grown on black clays soils at JNKVV,

College of agriculture, Indore collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) during 2002-04.

Methodology

Studies were carried out during the period from 2002 to 2004 at Ringnodia micro watershed. Ringnodia is located in western part of the state of Madhya Pradesh at 20 km distance from Indore city (22 º 51'N and 75º 51'E) on Indore-Ujjain highway at an altitude of about 540 m from the mean sea level and covers an area of 390 hectares. The watershed is located in the middle and lower reaches of *Khan* River. The soils of the Ringnodia micro-watershed are shallow to deep black with variable depth. They occur on bare hill slopes to flat topography. The cultivated soils are mostly clay loam in texture with high moisture retention capacity, normal to somewhat alkaline in reaction (soil pH 7.5 – 9.3), and electrical conductivity (EC values < 1.00 d S m^{-1} at 25 ºC for most soils indicating normal soils**.** The soils in general were neutral to slightly alkaline in reaction, with low to medium in soil fertility status with respect to available N, P and S, while they were high in K content. During the study period, the monsoon rains commenced in 23rd SMW i.e. between June 4 to June 10, which were normal scheduled period. There were 638.8 mm, 944.7, and 846.8 mm of rainfall occurred in 38,47and 45 rainy days during 2003-04, 2003-04 and 2004-05, respectively.

At Ringnodia micro-watershed, 22 hectares Vertisol area was delineated to study the effects of soil and water conservation measures and best bet options for increasing productivity through farmers' participatory on-farm trials. Various measures included renovation of existing water storage structures, construction of loose boulder structure, water diversion bunds, safe disposal of runoff during rainy season, planting of improved crops and cropping system, integrated nutrient management practices etc. Studies on the impact of conservation structures on ground water recharge and soil conservation, integrated nutrient management practices, impact of S, B application on productivity of soybean, crop diversification/ introduction of new or traditional crops including vegetables cultivation and floriculture, alternate land use and other miscellaneous Activities were carried out. The impact of all the considered management practices was assessed on the ground water recharge, crop diversification and productivity and profitability of crops after 3 years of experimentation.

Results and Discussion

Studies carried out during the year 2002-03 clearly revealed the positive impact of conservation structures on runoff reduction, soil erosion control, surface water storage in sorage structures, ground water recharge and productivity enhancement. Farmers of the watershed were convinced of using balanced nutrition particularly recommended levels of N, P_2O_5 and S to soybean at the rate of 30, 60 and 30 kg/ha respectively as it resulted in tremendous improvement in productivity and net returns over their own practice of using only 50 kg/ha diammonium phosphate applied as mixed with soybean seeds. Application of zinc at the rate of 25 kg/ha $ZnSO_4$ resulted in only marginal increase in the productivity of soybean.

Studies carried out during the year 2003-04 clearly revealed the positive impact of conservation structures, created 2- 3 years back, on runoff reduction, soil erosion control, surface water storage in storage structures, ground water recharge and productivity enhancement. Farmers of the watershed are now convinced of using balanced nutrition particularly recommended levels of N, P_2O_5, and S at the rates of 30, 60 and 20 kg/ha respectively and boron (2 foliar application at 30 and 45 DAS) and zinc (at the rate of 25 kg $ZnSO_4$ /ha, as soil application) to soybean as these resulted in tremendous improvement in productivity and net returns over their own practice of using only 50 kg/ha diammonium phosphate applied as mixed with soybean seeds.

Integrated nutrient management

Results of the experiments conducted during the year 2004 revealed that the monsoon rains commenced in 23rd SMW i.e. between June 4 to June 10, which was normal scheduled period. The monsoon terminated after the second week of October 2004. During the season there were 846.8 mm of rainfall with 45 rainy days recorded at station while the rainfall recorded in watershed was only 670 mm. Initially crops encountered 1 month duration dry spell and later on distribution was also erratic. Application of half of recommended levels of N and P at the rate of 15 and 30 kg/ha along with 4 t/ha of FYM resulted in 39.8% increase in seed yield and monetary returns over farmers' practice of nutrient management (Table 1 and 2). Highest seed yield of 1587 Kg/ha and monetary returns of Rs 19214/- per hectare was recorded in the treatment combination T3 (RDF + S @ 20 kg/ha through gypsum as basal application. Application of S along with RDF led to 88.2% increase in seed yield of soybean and 81.1% increase in economic returns, respectively over farmer's practice (Table 3 and 4).

The data presented in Table 5 and 6 Basal application of Zn @ 25 kg/ha $ZnSO_4$ along with RDF gave 10.70% higher yield than RDF i.e. 30 kg N/ha + 60 kgP_2O_5/ha and 46% higher yield (2190 kg/ha) over Farmer's practice i.e. 50 kg DAP/ha. This treatment fetched a net monetary return of Rs. 19466 per ha with highest B: C ratio of 3.78. Boron application (Table 7 and 8) led to significant and considerable increase in seed yield of soybean as due to treatment T2 (RDF- 30 kg N and 60 kg P_2O_5/ ha), T3 (RDF + B Foliar application), and T4 (RDF+ B+ S) was 45.5%, 48.5% and 53.7% respectively over farmer's practice (T1- Farmers practice i.e.50 kg DAP/ha).

Table 1: Seed and straw yield of soybean (JS-335) as influenced by different treatments [2002-04].

Locations/ Farmers	Seed and straw yield (kg/ha)								CD 5% for seed
	T1 (FP)		T2 (RDF)		T3 (1/2RDF+FYM)		T4(1/2 RDF+PSM +Rh)		
	Seed	Straw	Seed	Straw	Seed	straw	Seed	Straw	
Year	**2002-03**								
Mean (kg/ha)of 6 locations	728	1030	1032	1215	997	1188	923	1145	34.80
% Change over T1 (FP)	-	-	41.7	-	37	-	27		
Year	**2003-04**								
Mean (kg/ha) of 6 locations	687	932	993	1227	977	1192	782	1013	56.14
% Change over T1 (FP)	-	-	45	-	42	-	14	-	
Year	**2004-05**								

Mean (kg/ha)of 6 locations	1075	1292	1440	1732	1502	1787	1253	1510	66.95
++.% Change over T1 (FP)	-	-	+33.9	-	+39.8	-	+16.6	-	
Av. Of 3 years	830	1085	1155	1391	1159	1389	986	1223	-
% Change over FP	-	-	+39.2	-	+39.6	-	+18.8	-	-

Table 2: Monetary returns (Rs/ha) and benefit-cost ratio of soybean (JS-335) due to different treatments at Ringnodia micro-ws during 2002-04.

Treatments	Gross income (Rs/ha)				Benefit-Cost Ratio			
Year	**2002**	**2003**	**2004**	**Mean**	**2002**	**2003**	**2004**	**Mean**
T1- FP	7695	7926	13008	9543	1.68	1.57	2.36	1.87
T2- RDF	10806	11417	17426	13216 (+38.5)	2.03	1.96	2.58	2.19
T3- 1/2RDF+FYM	10445	11220	18162	13276 (+39.1)	1.83	1.78	2.83	2.15
T4- 1/2RDF+PSM+Rh	9688	9003	15168	11286 (+18.3)	2.07	1.60	2.54	2.07

Note: Figures in parentheses indicate% increase over farmer's practice (FP)

Table 3: Influence of sulphur application on productivity of soybean (JS-335) in Ringnodia micro-ws during 2002-04.

S. No.	Farmers name	T1- Farmers practice (50 Kg/ha DAP)		T2- RDF (30 kg N and 60 kg P_2O_5/ ha)- S		T3- RDF+ S (20-30 kg/ha by gypsum)		C.D. 5% for seed yield
		Seed	**Straw**	**Seed**	**Straw**	**Seed**	**Straw**	
2002-03	Mean (kg/ha)[15 locations]	572	751	837	1173	930	1263	38.40
	Change in seed yield over T1 (%)	-	-	46.1	-	62.55	-	
2003-04	Mean yield (Kg/ha) 20 locations	635	738	798	941	889	1038	28.41
	% Change in seed yield over T1 (%)	-	-	26	-	40	-	
2004-05	Mean seed yield (Kg/ha)- 10 locations	843	1098	1429	1769	1587	1934	47.20
	Increase in yield (%)	-	-	+69.5	-	+88.2	-	
Av. Yield of 3 years		683	862	1021	1294	1135	1412	-
Av.% Increase over FP		-	-	49.5	-	66.2		

Table 4: Monetary returns (Rs/ha) and benefit-cost ratio of soybean (JS-335) due to different treatments at Ringnodia micro-ws during 2002-2004.

Treatments	Monetary returns (Rs/ha)				Benefit-Cost Ratio			
Year	**2002 (15 Reps)**	**2003 (20 Reps)**	**2004 (35 Reps)**	**Mean**	**2002**	**2003**	**2004**	**Mean**
T1- FP	4500	7274	10162	7312	1.33	1.48	1.92	1.58
T2- RDF	5500	9154	17317	10657+45.8%	1.60	1.66	2.43	1.90
T3- RDF+S	5750	10202	19214	11722+60.3%	1.70	1.77	2.58	2.02

Table 5: Influence of zinc application on productivity of soybean (JS-335) in Ringnodia micro-ws during 2002-04.

Locations/ Farmers	Seed and sraw yield (kg/ha)					
	T1 (FP) (50 kg/ha DAP and no Zn application		**T2 (RDF) (30 kg N and 60 kg P_2O_5/ha)**		**T3 (RDF+Zn) (T2 + 25 kg $ZnSO_4$/ha)**	
	Seed	**Straw**	**Seed**	**Straw**	**Seed**	**straw**
2002-03 Mean						
Mean Seed yield (kg/ha) (4 locations)	588	799	842	1155	889	544
Change in seed yield over T1 (%)	-	-	43.4	-	51.4	-
2003-04						
Mean Seed yield (kg/ha) (4 locations)	698	600	905	1040	973	1156
Change in seed yield over T1 (%)	-	-	29.70%	-	39.42%	-
2004-05						
Mean Seed yield (kg/ha) (4 locations)	1500	1830	1977	2338	2190	2563
Change in seed yield over T1 (%)	-	-	31.80	-	46.00	-
Av. Yield of 3 years	929	1076	1241	1511	1351	1421
% Change over FP	-	-	+33.6	-	+45.4	-

Table 6: Monetary returns (Rs/ha) and benefit-cost ratio of soybean (JS-335) due to different treatments at Ringnodia micro-ws during 2003-04.

Treatments	Monitory returns (Rs/ha)			Benefit-Cost Ratio		
Year	**2003**	**2004**	**Mean**	**2003**	**2004**	**Mean**
Farmers practice i.e.50 kg DAP/ha	8002	18165	13084	1.6	3.30	2.45
RDF i.e. 30 kg N+ 60 kg P_2O_5	10371	23910	17141 (+31.0%)	1.78	3.73	2.76
RDF+ 25 kg Zn SO_4/ha	11159	6466	18813 (+43.8%)	1.74	3.78	2.77

Table 7: Influence of Boron application on productivity of soybean (JS 335) in Ringnodia Micro watershed [2003-04&2004-05]

Year & (Locations)	Parameters	T1- Farmers practice i.e.50 kg DAP/ha	T2- RDF (30 kg N and 60 kg P_2O_5/ ha)	T3- RDF + B (2 Folior application)	T4- RDF+ B+S	CD 5% for seed yield
2003-04 (5)	Mean yield (Kg/ha)	642	802	794	908	57.46
	% Change in yield over	-	25	24	41	-

	Farmers' Pracrtice					
2004-05 (5)	Mean yield (Kg/ha)	808	1176	1200	1242	84.36
	% Change in yield over Farmers' Pracrtice	-	+ 45.5%	+ 48.5%	+ 53.7%	
Av. Yield of 3 years		725	989	997	1075	-
% Change over FP		-	36.4	37.5	48.3	-

Table 8: Monetory returns (Rs/ha) and benefit-cost ratio of soybean (JS-335) due to different treatments at Ringnodia micro-ws during 2003-04.

Treatments	Monitory returns (Rs/ha)			Benefit-Cost Ratio		
Year	2003	2004	Mean	2003	2004	Mean
T1-Farmers practice i.e.50 kg DAP/ha	7364	9838	8601	1.47	1.79	1.63
T2-RDF (30 kg N and 60 kg P_2O_5/ ha)	9191	14247	11719 (+36.2%)	1.58	2.23	1.91
T3-RDF +B(Folior application)	9102	14548	11825 (+37.5%)	1.51	2.26	1.89
T4-RDF+ B+S	10426	15046	12736 (+48.1%)	1.66	2.31	1.99

Crop Residue Recycling

The NADEP *Tankas* were constructed at farmer's field during Kharif season and the prepared compost was recycled in wheat fields along with farmer's practice of fertilizer application and yield data are presented in Table 9. It is evident from the data that average wheat yields are increased by 12 percent due to application of NADEP compost as compared to FP. Since it is first year of the application of compost therefore% increase is not very high. Continuous use of compost will certainly enhance the crop productivity apart from improving the soil quality in long run.

Table 9: Effect of recycling of crop residue through NADEP compost on the grain and straw yield of wheat (2004-05)

S. No.	Farmers Name	FP: 60: 30 kg N and P_2O_5 per ha		60: 30 kg N and P_2O_5 per ha + NADEP compost @ 5t/ha	
		Grain (kg/ha)	Straw (kg/ha)	Grain (kg/ha)	Straw (kg/ha)
	Mean [5 locations]	1928	2148	2160	2392
% Increase over farmer's practice		-	-	12.00	11.30

Impact of various soil conservation measures on ground water recharge

There has been tremendous positive impact of various natural resource conservation activities (water storage structure, diversion bunds, loose boulder structures, desilting of ponds and plugging of natural drains and gully etc. and constructions of on soil erosion control, ground water recharge and thereby increase in the life of open dug wells and tube wells in the watershed (Tables 10- 12).

Various interventions suggested that water and soil conservation measures were paramount to overall development of the watershed. Augmenting water resources was the major concern of the most farmers. However, to translate collective concern into collective action was a major challenge. As a result of these collective endeavors, various soil and water conservation measures could be undertaken which led to appreciable reduction in soil and water loss, increased water tables in the wells and create a storage penitential to harvest 70% of the runoff. At individual level, farmers were innovative, and were always eager to test new technologies such as extra-short-duration pigeonpea, intercropping with pigeonpea, broadbed and furrows, mini-ridges, and gypsum application. Their overall perception about few of these is encouraging. Results revealed that water level rised due to well recharge. In the treated section, where the soil conservation works were done, water remained available in most of the well throughout the year, even in the year of less rainfall. The water level in treated section exhibited a wide difference in percentage change over untreated section during the year 2004. This reflects the importance of the soil and water conservation measure to maintain the water level.

Table 10: Runoff and soil loss measured in the Ringnodia micro watershed (2003-04)

Rainfall (mm)	Sections of WS	
	Treated (28.5 ha)	Untreated (22.5 ha)
Seasonal runoff (mm)	40.8	101.5
Runoff as% of rainfall	3.80	8.40
Peak rate of runoff (cum/sec/ha)	0.0011	0.0019 cum/sec/ha
Soil Loss (t/ha)	0.3448	2.4376
Total seasonal rainfall = 1225 mm		

Table 11: Water storage structure created in a natural drain in Ringnodia micro-watershed loose boulder structures and gunny bags loose boulder structures and gunny bags during June 2004.

S. No.	Length of existing gully (m)	Width of existing gully (m)	Depth of existing gully (m)	Storage capacity (Cum)
1	45	15	1.5	1012.5
2	45	15	1.5	1012.5
3	45	15	1.0	675.0
Total Storage capacity (Cum)				2700.0

Table 12: Impact of boulder structures (Rock-fill) with wire mesh binding on silt deposition in up streamside of rock-fill structure.

Year	Ist structure (cm)	IInd structure (cm)	Average silt deposition (cm)
2002	4	6	5.0
2003	5	5	5.0
2004	3	4	3.5
Total	12	15	-

Conclusion

The main conclusions emanated from the results of the studies are; (i) Application of half of recommended levels of N and P at the rate of 15 and 30 kg/ha along with 4 t/ha of FYM (T3) resulted in 39.8% increase in seed yield and monitory returns over farmers' practice of nutrient management, (ii) Highest seed yield of 1587 Kg/ha and monitory returns of Rs 19214/- per hectare was recorded in the treatment combination T3 (RDF + S @ 20 kg/ha through gypsum as basal application. Application of S along with RDF led to 88.2% increase in seed yield of soybean and 81.1% increase in economic returns, respectively over farmer's practice, (iii). Boron application led to significant and considerable increase in seed yield of soybean as due to treatment T2 (RDF- 30 kg N and 60 kg P_2O_5/ ha), T3 (RDF + B Foliar application), and T4 (RDF+ B+ S) was 45.5%, 48.5% and 53.7% respectively over farmer's practice (T1- Farmers practice i.e.50 kg DAP/ha), (iv). Basal application of Zn @ 25 kg/ha $ZnSO_4$ along with RDF gave 10.70% higher yield than RDF i.e. 30 kg N/ha + 60 kgP_2O_5/ha and 46% higher yield (2190 kg/ha) over Farmer's practice i.e. 50 kg DAP/ha. This treatment fetched a net monitory return of Rs. 19466 per ha with highest B: C ratio of 3.78, (v) Farmers came forward to recycle crop residues by making compost using NADEP tankas. Compost has been applied before planting of Rabi crops, (vi). Due to enhanced availability of water for irrigation, farmers have started cultivating vegetable crops and floriculture which has helped in increasing their income tremendously, (vii). There has been tremendous positive impact of various natural resource conservation activities (water storage structure, diversion bunds, loose boulder structures, de-silting of ponds and plugging of natural drains and gully etc and constructions of on soil erosion control, ground water recharge and thereby increase in the life of open dug wells and tube wells in the watershed.

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