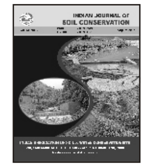
Vol. 43, No. 2, pp 166-169, 2015
Indian Journal of Soil Conservation
Online URL:http://indianjournals.com/ijor.aspx?target=ijor:ijsc&type=home



Crop production through diversion systems of rain water management in hillocks area of Bundelkhand

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ARTICLE INFO

Article history :
Received : February, 2014
Revised : January, 2015
Accepted : March, 2015

Key words :
Diversion system,
Hill bottom,
Hill and valley ecosystems,
Rolling topography,
Stony and gravelly land

ABSTRACT

A study was conducted on management with diversion systems during 2009 and 2010 in catchments of river Betawa in Jhararghat, Shahpur Verma and Verma Bihar villages of Talbehat block, Lalitpur, Uttar Pradesh. The objective was to increase the feasibility of crop cultivation through double cropping systems in hill and valley ecosystem, where mono cropping with mono culture is in vogue in piecemeal. The treatments *viz.,* conventional system (CS), runoff recharge in stony dug wells (RRSW), runoff harvesting at hill bottom in natural water impounding structure (NWIS) and runoff collection in constructed water storage structure (CWSS) were tested in the operational area. In double cropping system of sesamum-chickpea and sesamum-Indian mustard, sesamum gave higher yield of 580 kg ha^{-1} and 570 kg ha^{-1}, respectively under management through runoff collection in constructed water storage structure (CWSS) over the yield recorded in other systems of moisture management. Chickpea and Indian mustard grown after sesamum under management through CWSS gave significantly higher yield of 1890 kg ha^{-1} and 2240 kg ha^{-1}, respectively as compared to other moisture management practices. The management through CWSS yielded significantly higher blackgram (830 kg ha^{-1}) as compared to yield recorded in runoff harvesting at hill bottom in natural water impounding structure (NWIS), recharge ground water in stony dug wells (RRSW) and conventional system (CS) under black gram-wheat cropping system. Similarly, highest wheat yield of 4850 kg ha^{-1} was also recorded in management through CWSS, which was significantly superior over other practices of soil moisture management.

1. INTRODUCTION

The barren hillock ridges and rock out crops are grown on area of 0.21 m ha in Chitrakoot, Mahoba, Banda, Jhansi, Lalitpur and Hamirpur district of Bundelkhand region of Uttar Pradesh (Anonymous, 2012). Intermittent patches with shallow skeletal soil on sloppy land are also found, which are covered by grasses and shrubs. The stony and gravelly lands normally found on rolling topography, which have been subjected to heavy grazing or indiscriminate felling of trees. This area is characterized by limited arable land with highly fragmented holdings, poor irrigation facilities, less productive marginal and step sloping land and mining for ballast. This area also suffers from the poor supply of organic manures, chemical fertilizers and other improved agricultural inputs due to absence of marketing facilities. The poor or landless house holds of the area depend on forests and public land for livestock rearing and any restriction to these affect their livelihood (Singh *et.al.,* 2009).

Singh *et al.* (2011) reported that the hill and valley eco-system was most suitable for pasture land through natural palatable grasses. The holistic development of hillocks degraded eco-system is only possible with the adoption of watershed technology as reported by Singh *et al.* (2011). The erosion hazards are greater under cereals and millet crops cultivation during rainy season in hillocks and valley area. Singh (2011) reported that black gram and sesamum were effective in reducing runoff and soil loss as compared to cereals and millet crops. To reduce runoff and soil loss, broad leaf crop sesamum and cover crop black gram were selected. In addition to this, the soil of this hillocks and valley area is most suitable for sesamum and black gram cultivation after adopting proper soil and water management.

The objective of present study was to close the over grazing and felling of trees and utilize the hill ridges and valley area to agriculture and exploit the rain water in irrigations through runoff harvesting.

2. MATERIALS AND METHODS

The degraded land of hillocks area (1650 ha) was selected in Lalitpur district of Bundelkhand region, which lies in the catchments of river Betawa in Jhararghat, Shahpur Verma and Verma Bihar villages of Talbehat block. The pilot area of watershed is located between $24^0 11^{'}$-$26^0 27^{'}$ N latitude and $78^0 17^{'}$ - $81^0 34^{'}$ E longitude at an elevation of 300 m above msl. For rain water management, area was treated with different soil conservation measures. The experimental site is loam (Parwa and mixed Kabar), having pH 8.0, organic carbon 0.53%, total nitrogen 0.05%, available P 9.70 kg ha^{-1}, and available K 265 kg ha^{-1}; therefore, the fertility status was low. The much emphasis was given on the construction and management of runoff recharge in stony dug wells (RRWS), natural water impounding structures (NWIS) and construction of water storage structures (CWSS) for runoff harvesting during rainy season and its exploitation for life saving irrigations. The subjected area selected under Farmers Participatory Action Research Programme on Water/Rain Water Harvesting (Scheme of Ministry of Water Resources, New Delhi) for carrying out the research programme on important technologies of water harvesting including rain water management with diversion systems during 2009 and 2010. The rainfall received during 2009 and 2010 was 940 and 952 mm, respectively. The ten years (2001 to 2010) mean annual rainfall of watershed area was 972 mm.

The treatments comprised conventional system (CS-T_1), runoff detention through diversion system with biological inter- terrace and recharge ground water in stony dug wells (RRSW-T_2), runoff harvesting at hill bottom through diversion system in natural water impounding structure (NWIS-T_3) and runoff collection through diversion system in constructed water storage structure (CWSS-T_4). The subjected area under T_1, T_2, T_3 and T_4 treatments was 395, 510, 478 and 267 ha, out of which 0.25 ha area selected under each rain water management (RWM) system and each RWM system replicated on nine farmers' fields. The rainfall was collected in hillocks area with diversion system from the various part of operational area in RRSW, NWIS and CWSS constructed/maintained in the catchments area. The stored water was utilized for life saving irrigations during dry spells of monsoon season as well as winter season experimental crops through lifting and siphoning system of irrigation. The remaining excess water after impounding in water storage structures was discharged in to the near by drainage system.

Three cropping systems *i.e.,* sesamum-chickpea, blackgram-wheat and sesamum-Indian mustard were followed under each rain water management system. Crop varieties “Pragati”, “Azad Urd-3”, “T 59”, “K 9423” and “KPG 59” for sesamum (*Sesamum orientale*), blackgram (*Phaseolus mungo*), Indian mustard (*Brassica juncea*), wheat (*Triticum aestivum*) and chickpea (*Cicer arietinum*) crops, respectively, were sown under double cropping system in study area. Sesamum and blackgram were sown after onset of rainfall in last week of July and harvested at 80 to 85 days after sowing during both the seasons. Chickpea, wheat and Indian mustard were seeded after pre-sowing irrigation with impounded water in the second fortnight of November and harvested after 120-125 days of planting under sesamum-chickpea, blackgram-wheat and sesamum-Indian mustard cropping systems. The recommended dose of NPKS was supplied @ 30:15:15:25 kg ha^{-1} to sesamum, 15:40:00:20 kg ha^{-1} to blackgram, 120:60:40:30 kg ha^{-1} to wheat,120:60:60:40 kg ha^{-1} to Indian mustard and 20:60:20:20 kg ha^{-1} to chickpea. One life saving irrigation was given during *kharif* season crops at moisture stress condition after 45 days of sowing of both the crops. Three life saving irrigations were given to wheat, Indian mustard and chickpea at 30, 60 and 90 days after sowing from harvested water.

The production efficiency value in term of kg $ha^{-1}day^{-1}$ was calculated with following formula:

$$\text{Production efficiency value (kg ha}^{-1}\text{day}^{-1}) = \frac{\text{Equivalent yield of wheat/Indian mustard/chickpea in crop rotations}}{\text{Total duration of crops in that rotation}}$$

Water use efficiency was calculated with the help of following formula:

$$\text{Water use efficiency (kg ha}^{-1}\text{mm}^{-1}) = \frac{\text{Grain yield (kg ha}^{-1})}{\text{Total water applied (mm)}}$$

The individual year's data and pooled data of two years were statistically analyzed with the standard methods as described by Gomez and Gomez (1984). The results of the study were discussed year wise based on mean value of two years.

3. RESULTS AND DISCUSSION

Productivity of Cropping Systems

Sesamum gave highest seed yield of 580 kg ha^{-1} under CWSS (T_4) closely followed by NWIS (560 kg ha^{-1}) in sesamum-chickpea cropping system. Sesamum yield was 520 kg ha^{-1} in RRSW (T_2) and 250 kg ha^{-1} in conventional system (T_1). The highest chickpea yield of 1890 kg ha^{-1} was obtained with rain water harvesting in CWSS and lowest was in conventional system (1570 kg ha^{-1}).

In blackgram-wheat cropping system, rain water harvesting in CWSS (T_4) gave highest blackgram yield of 830 kg ha^{-1} while conventional system (T_1) resulted lowest yield of 350 kg ha^{-1}. Rain water management through NWIS and RRSW gave blackgram yield of 770 kg ha^{-1} and 710 kg ha^{-1} , which were lowest by a margin of 60 kg ha^{-1} or 7.79% and 120 kg ha^{-1} or 16.90%, respectively, in comparison to rain water management through CWSS (T_4) as indicated in Table 1. Similarly, highest wheat yield of 4850 kg ha^{-1} was obtained under rain water management through CWSS (T_4), which was significantly superior in comparison to conventional system of moisture management. Wheat yield of 3115 kg ha^{-1}, 4735 kg ha^{-1} and 4800 kg ha^{-1} was obtained in conventional, RRSW and NWIS systems of rain water management, respectively.

Sesamum gave highest yield by 570 kg ha^{-1} under rain water management with CWSS (T_4) closely followed by rain water management through NWIS (550 kg ha^{-1}) in sesamum-Indian mustard cropping system. The highest Indian mustard yield of 2240 kg ha^{-1} was found under rain water management through CWSS (T_4) and lowest was in conventional system (1670 kg ha^{-1}). The rain water management through RRSW and NWIS gave Indian mustard yield between these two limits in sesamum-Indian mustard cropping system.

The highest equivalent yield of chickpea, wheat and Indian mustard was obtained under rain water management through CWSS (T_4) by 3547 kg ha^{-1}, 7755 kg ha^{-1} and 3726 kg ha^{-1}, respectively, under sesamum-chickpea, blackgram- wheat and sesamum-Indian mustard crop rotations. The lowest equivalent yield of chickpea (2284 kg ha^{-1}), wheat (4340 kg ha^{-1}) and Indian mustard (2374 kg ha^{-1}) was in conventional system under sesamum-chickpea, blackgram-wheat and sesamum-Indian mustard cropping systems. Rain water management through NWIS (T_3) produced equivalent yield by 3475 kg ha^{-1} of chickpea, 7495 kg ha^{-1} of wheat and 3644 kg ha^{-1} of Indian mustard. Similarly, rain water management through RRSW (T_2) gave equivalent yield by 3335 kg ha^{-1} of chickpea, 7220 kg ha^{-1} of wheat and 3548 kg ha^{-1} of Indian mustard. Reduction was noted in equivalent yield of chickpea, wheat and Indian mustard in RRSW (T_2) and NWIS (T_3) as compared to rain water management through CWSS (T_4) but much improvement noted over conventional system of moisture management (T_1).

The increase in grain yield of different crops under rain water harvesting in NWIS and CWSS was due to increased in time of soil moisture availability, supplied by life saving irrigations, which added the positive effect on growth and development phases of plants and also created the suitable micro- climate during crop period. Studies of Goyal *et al.* (2007), Sanjeeva Reddy *et al.* (2009), Singh (2011), Patil *et al.* (2011), Jat *et al.* (2013) and Ranade (2014) also revealed that the variation in amount of moisture conserved, time of moisture depletion and moisture management through life saving irrigations with impounded rain water was maintained the yield levels of *kharif* and *rabi* season crops.

Production Efficiency

The production efficiency value was worked out on chickpea, wheat and Indian mustard equivalent yield basis of respective crop rotation (Table 1). Production efficiency value in term of kg ha^{-1}day^{-1} was significantly increased due to rain water management through RRSW (T_2), NWIS (T_3) and CWSS (T_4) over the conventional system (T_1) of moisture management. The maximum production efficiency value in term of kg ha^{-1}day^{-1} was noted under each cropping system of rainwater management through CWSS.

Water Use Efficiency

The water use efficiency was recorded 3.13 kg ha^{-1}mm^{-1} of water in sesamum and 9.00 kg ha^{-1} mm^{-1} of water in chickpea under sesamum-chickpea cropping system and 3.25 kg ha^{-1} mm^{-1} of water in blackgram and 23.09 kg ha^{-1} mm^{-1} of water in wheat under black gram-wheat cropping system while it was 3.08 kg ha^{-1}mm^{-1} of water in sesamum and 10.66 kg ha^{-1}mm^{-1} of water in Indian mustard under sesamum-Indian mustard cropping system when rain water harvested in CWSS (Table 2). The water use efficiency recorded in all tested crop under T_4 was higher over T_1 and T_2 but almost at par with T_3. The water use efficiency increased with increase in grain yield and moisture management practices under dry land condition of hillocks area and also had been reported by Singh (2011).

Table: 1
Yield and production efficiency value of different cropping systems under rain water management methods

Rain water management system	Cropping system	Yield (kg ha^{-1})						Production efficiency value		
		Kharif crop			*Rabi* crop			Chickpea/wheat/ Indian mustard equivalent yield (kg ha^{-1})	Total duration (day)	Production efficiency value (kg ha^{-1}day^{-1})
		I year	II year	Mean	I year	II year	Mean			
T_1 - Conventional system (CS)	Sesamum-chickpea	247	253	250	1566	1574	1570	2284	205	11.14
	Black gram-wheat	345	355	350	3110	3120	3115	4340	205	21.17
	Sesamum-Indian mustard	266	274	270	1665	1675	1670	2374	200	11.87
T_2 - Recharge ground water in stony dug wells (RRSW)	Sesamum-chickpea	515	525	520	1845	1855	1850	3335	205	16.26
	Black gram-wheat	700	720	710	4730	4740	4735	7220	205	35.21
	Sesamum-Indian mustard	535	545	540	2145	2135	2140	3548	200	17.74
T_3 - Runoff harvesting at hill bottom in natural water impounding structure (NWIS)	Sesamum-chickpea	562	558	560	1870	1880	1875	3475	205	16.95
	Black gram-wheat	770	770	770	4795	4805	4800	7495	205	36.56
	Sesamum-Indian mustard	548	552	550	2200	2220	2210	3644	200	18.22
T_4 - Runoff collection in constructed water storage structure (CWSS)	Sesamum-chickpea	575	585	580	1885	1895	1890	3547	205	17.30
	Black gram-wheat	825	835	830	4848	4852	4850	7755	205	37.82
	Sesamum-Indian mustard	560	580	570	2230	2250	2240	3726	200	18.63
C.D. (P. = 0.05)	-	47	28	22	27	26	16	23	-	1.21

Table: 2
Water use efficiency as influenced by different systems of rain water management

Rain water management system	Cropping system	Crop	Harvested rain water (hectometer)	No. of irrigation	Depth of irrigation (mm)	Total depth of irrigation (mm)	Effective rains (mm)	Total water use (mm)	Yield (kg ha^{-1})	Water use efficiency (kg ha^{-1} mm^{-1})
T_1 - Conventional system (CS)	Sesamum-chickpea	Sesamum	21.00	1	60	60	125	185	250	01.35
		Chickpea		3	60	180	30	210	1570	07.47
	Blackgram-wheat	Blackgram		1	60	60	195	255	350	01.37
		Wheat		3	60	180	30	210	3115	14.83
	Sesamum-mustard	Sesamum		1	60	60	125	185	270	01.45
		Mustard		3	60	180	30	210	1670	07.95
T_2 - Recharge ground water in stony dug wells (RRSW)	Sesamum-chickpea	Sesamum	33.00	1	60	60	125	185	520	02.81
		Chickpea		3	60	180	30	210	1850	08.80
	Blackgram-wheat	Blackgram		1	60	60	195	255	710	02.78
		Wheat		3	60	180	30	210	4735	22.54
	Sesamum-mustard	Sesamum		1	60	60	125	185	540	02.91
		Mustard		3	60	180	30	210	2140	10.19
T_3 - Runoff harvesting at hill bottom in natural water impounding structure (NWIS)	Sesamum-chickpea	Sesamum	43.00	1	60	60	125	185	560	03.02
		Chickpea		3	60	180	30	210	1875	08.92
	Blackgram-wheat	Blackgram		1	60	60	195	255	770	03.01
		Wheat		3	60	180	30	210	4800	22.85
	Sesamum-mustard	Sesamum		1	60	60	125	185	550	02.97
		Mustard		3	60	180	30	210	2210	10.52
T_4 - Runoff collection in constructed water storage structure (CWSS)	Sesamum-chickpea	Sesamum	61.00	1	60	60	125	185	580	03.13
		Chickpea		3	60	180	30	210	1890	09.00
	Blackgram-wheat	Blackgram		1	60	60	195	255	830	03.25
		Wheat		3	60	180	30	210	4850	23.09
	Sesamum-mustard	Sesamum		1	60	60	125	185	570	03.08
		Mustard		3	60	180	30	210	2240	10.66

4. CONCLUSIONS

The dryland farming in hill and valley area of Bundelkhand will continue to play a dominant role in country's food production. However, soils in this region are not only thirsty but also hungry particularly for nutrients. The yield under dryland agriculture in hillocks area can be increased through proper selection of crops, varieties and judicious rain water management practices. On the basis of experiment conducted, it may be inferred that the sesamum-chickpea, blackgram-wheat and sesamum-Indian mustard cropping system were found best for higher productivity under rain water harvesting through CWSS on reclaimed hill and valley ecosystem. The management of rain water through runoff harvesting in CWSS is suitable for hill and valley eco- system of Bundelkhand. This can be replicated for other part of Bundelkhand region of India in similar climatic conditions.

REFERENCES

Anonymous. 2012. Uttar Pradesh Kai Krishi Ankarey. Publication of Department of Agriculture, U.P. Lucknow, 16 p.

Gomez, K.A. and Gomez, A.A. 1984. Statistical procedures for agricultural research. Johnwiley and Sons, New York.

Goyal, R.K., Bhati, T.K. and Ojasvi, P.R. 2007. Performance evaluation of some soil and water conservation measures in hot arid zone of India. *Ind. J. Soil Cons.,* 35(1): 58-63.

Jat, M.L., Sharma, S.K., Kothari, A.K., Sharma, R.K., Pareek, K. and Kumari, M. 2013. Moisture conservation practices in blackgram for pulse security in semi-arid tropics. *Ind. J. Soil Cons.*, 41(2): 158-162.

Patil, S.L., Sheelavantar, M.N. and Shashidhar, K.C. 2011. Growth and yield of winter sorghum (*Sorghum bicolor* (L.) Moench) as influenced by rain water conservation practices, organic material and nitrogen application in Vertisols of Semi Arid Tropical India, *Ind. J. Soil Cons.*, 39(1): 50-58.

Ranade, D.H. 2014. Economic evaluation of irrigation through water harvesting tanks in Malwa region. *Ind. J. Soil Cons*., 42(2): 209-215.

Sanjeeva Reddy, B., Maruthi, V., Adake, R.V. and Mandal, U.K. 2009. Effect of different land configuration practices on productivity of sorghum-pigeon pea intercropping system in Shallow Alfisols. *Ind. J. Dryland Agric. Dev*., 24(1): 57-62.

Singh, R.A. 2011. Rain water management with three systems in ravines affected area of Bundelkhand. *Ind. J. Soil Cons.*, 39(1): 14-19.

Singh, R.A., Singh, J., Chandra, S. and Singh, S. 2011. Fodder and grasses production on rangeland of dry eco-system for scaling up of milk productivity. *Int . J. For. Crop Imp.,* 2(2): 147-148.

Singh, R.A., Singh, P.V., Shamim, M., Singh, M.K. and Sharma, V.K., 2009. Integrated development of natural resources in hill and valley eco-system through rain water management technology. *Int. J. Agric. Sci.*, 5(1): 284-288.