Indian J. Dryland Agric. Res. & Dev. 2016 31(2) : 27-30 10.5958/2231-6701.2016.00020.8

Effect of *in-situ* Moisture Conservation Methods on Productivity in North Eastern Ghat Zone of Odisha

S.K. Behera[1], D.K. Bastia[1] and A. Mishra[2]

[1]*AICRP for Dry Land Agriculture (OUAT), Phulbani, Kandhamal-762 001, Odisha*
[2]*AICRP for Potato (OUAT), Bhubaneswar-751 003, Odisha*

Email: subrat_behera@rediffmail.com

ABSTRACT: The study was conducted in the Budhadani village of Kandhamal District in north eastern ghat zone of Odisha under the National Innovations on Climate Resilient Agriculture (NICRA) programme of AICRP for Dry Land Agriculture, Phulbani, Odisha during *kharif* 2014 and 2015. Budhadani village always experiences scarce and erratic monsoon rainfall during *kharif* season. Practice of sole cropping was predominant in this area and often resulted in low yields or sometimes crop failure due to erratic monsoon rainfall. In such areas, *in-situ* moisture conservation methods and intercropping system are feasible options to minimize risk in crop production and ensure reasonable returns. The study was conducted for the cropping system as such sole maize, maize + cowpea (2:2) intercropping and maize + pigeon pea (2:2) intercropping system. In this experiment, three *in-situ* moisture conservation methods such as (i) summer ploughing, (ii) increase bund height and (iii) both summer ploughing and increase bund height were compared with the control treatment with no moisture conservation measures. Among the different moisture conservation methods, summer ploughing with increased bund height resulted in higher yield as compared to control treatment and other moisture conservation methods. Intercropping of rainfed crops such as maize + cowpea and maize + pigeon pea is an important risk minimizing strategy for drought proofing in the scarce rainfall zones.

Key words: Bund height; drought, intercropping system; *In-situ* moisture conservation; summer ploughing

Introduction

Limited and erratic rainfall in the rainfed area creates moisture stress conditions during the various critical growth stages of crop, resulting in severe yield reduction. In the rainfed areas of north eastern ghat zone of Odisha, even when the rainfall is high, most of the rainwater is lost as runoff and very litter quantity of rainwater is available for the crop production. Moisture conservation therefore plays a key role in the successful crop production during *kharif* season in dryland areas.

The uneven distribution of rainfall in time and space often causes dry spells of two weeks or more resulting in moisture stress conditions which results decline in productivity due to low soil water storage capacity (Sur *et al.,* 1992). Thus, the major constraint for establishing a crop is the lack of adequate moisture in the root zone (Hadda *et al.,* 2000; Bhatt *et al.,* 2004) The area therefore, requires adoption of location specific *in-situ* soil moisture conservation technologies by which the area could be ecologically rehabilitated and its production potential could be realized on a sustained basis. Summer ploughing, bund height and mulching are the most important and agronomic measures, that have been reported to reduce soil erosion and increase *in-situ* soil moisture storage and productivity of crops (Hadda *et al.,* 2005; Bhatt *et al.,* 2004).

The agricultural operations of the farmers of Orissa starts with land preparation for *kharif* crop just before the arrival of monsoon and ends after the harvest of *rabi* crop. Very few farmers go for summer crops. Whether it is rainfed or irrigated farming, land preparation is essential. The operation of summer ploughing is the first and foremost operation of land preparation. It is as essential as the insecticide or fertilizers for better productivity of crop. Summer ploughing is defined as the ploughing the field across the slope during hot summer with the help of specialized tools with primary objective of opening of the soil crust accompanied by deep ploughing and simultaneously overturning of the soil underneath to disinfect it with the help of piercing sun rays. Summer ploughing is an operation of ploughing which is done well in ahead of arrival of monsoon, in hot summer (April and May) with specific purpose (Nalatwadmath *et al.,* 2008).

Bunding is the construction of small embankments across the slope of the land to prevent erosion and promote better utilization of rainwater. All through the years, field bunding has proved to be one of the most effective interventions in conserving moisture and in the long term reduces land degradation. It is very common techniques being used for all over India as well as in Orissa (Selvaraju and Balasubramanian, 2001).

In north eastern ghat zone of Odisha, the practice of sole cropping is predominant but is risky and often results in low yields or sometimes results in crop failure due to erratic monsoon rainfall. In such areas, intercropping is a feasible option to minimize risk in crop production, ensure reasonable returns at least from the intercrop and also improve soil fertility with a legume intercrop. Paddy, maize, radish, pigeonpea and millets are the major crops. Intercropping of these crops is more profitable and is a key drought coping strategy (Behera *et al.,* 2012; Behera *et al.,* 2005).

Hence, the present investigation was conducted to find out the most efficient and adoptable *in-situ* moisture conservation technique and suitable cropping system for increasing the productivity under rainfed conditions.

Materials and Methods

The experiment was carried out in the village Budhadani of Kandhamal district under the National Innovations on Climate Resilient Agriculture (NICRA) programme of AICRP for Dryland Agriculture, Phulbani, Odisha during *kharif* season of 2014 and 2015. It is located in north eastern ghat zone of Odisha with a latitude of 19^0 34' to 20^0 34' North, longitude of 80^0 30' to 84^0 35' East and an elevation of 518 m above mean sea level. The soil at the experimental site was sandy loam and slightly acidic (pH 5.2 to 6.5). The details of soil texture and physico-chemical properties in different soil layers of Budhadani village are given in Table 1.

Table 1 : Soil texture and physico-chemical properties in different soil layers of Budhadani village

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Textural class	pH	EC (dS/m)	OC (%)
0-15	66.6	14	19.4	Sandy loam	5.2	0.07	0.24
15-30	64.9	13	22.1	Sandy clay loam	5.2	0.03	0.16
30-45	63.5	11	25.5	Sandy clay loam	6.0	0.02	0.16
45-60	50.6	10	39.4	Sandy clay	6.3	0.02	0.10
60-90	49.5	10	40.5	Sandy clay	6.5	0.02	0.07

Before inception of the NICRA programme in the village, the farmers in the villages were cultivating rice, local arhar (kandula), maize, radish etc but were not receiving desired returns due to use of local varieties and poor irrigation and water management of crops. In the present investigation, an attempt has been made to evaluate the effect of different *in-situ* moisture conservation technique such as summer ploughing, increase bund height, both summer ploughing and increase bund height and their impact on yield and economics of maize and maize based intercropping systems such as sole maize, maize + cowpea (2:2) and maize + pigeon pea (2:2). The intervention was made with improved varieties of crops and intercropping systems. Improved varieties of maize (hybrid NMH 51) and maize based intercropping system such as maize (hybrid NMH 51) + cowpea (cv. Gomti) and maize (hybrid NMH 51) + pigeonpea (cv. NTL-724) has been used in the village. For maize, crops were sown in line spacing of 60 cm and plant spacing of 30 cm. For all the intercropping systems, lines were drawn 30 cm apart and component crops were sown in lines with specific proportion. The fertilizer dose in maize based intercropping systems was 70-50-40 kg N-P_2O_5-K_2O/ha. Summer ploughing was done during the month of May. Crops were sown/ planted just after onset of monsoon. Bund of the field has been strengthened and increased the height up to 30 cm.

The experiment comprised of 12 treatments such as 4 treatments of different in situ moisture conservation technique such as control (M_1), summer ploughing (M_2), increase bund height (M_3), both summer ploughing and increase bund height (M_4); 3 treatments of maize based intercropping systems such as sole maize (C_1), maize + cowpea (C_2) and maize + pigeon pea (C_3).

The total rainfall during *kharif* 2014 and 2015 were 1413.1 mm and 778.8 mm, respectively which is 13.4% higher and 37.5% less rainfall than the normal rainfall, respectively. The occurrence of dry spells during the crop growing season during 2014 and 2015 are given in the Table 2.

Table 2 : Dry spells during the crop growing season (June to December) during 2014 and 2015

Dry spell during 2014		Dry spell during 2015	
Period	Duration (Days)	Period	Duration (Days)
10^{th}-17^{th} June	8	5^{th}-8^{th} July	5
28^{th}-31^{st} June	4	13^{th}-21^{st} July	9
16^{th}-19^{th} September	4	3^{rd}-13^{th} August	11
1^{st}-11^{th} October	12	2^{nd}-12^{th} September	11
18^{th}-26^{th} October	9	22^{nd} Sept.-31^{st} Oct.	39

Yield data of pure crops and intercrops was transformed to maize equivalent yield (t/ha) for comparison on the basis of market price. The values of maize equivalent yield (MEY) were computed by using the formula of (Behera *et al.,* 2012).

$$MEY = Y_m + \frac{(Y_i \times P_i)}{P_m}$$

Where, Y_m is grain yield of maize, Y_i is grain yield of intercrop, P_i is price of intercrop and P_m is price of maize

Three clusters were regarded as three replications and data was analyzed as per randomized block design following Gomez and Gomez (1984). Periodical observation of growth and yield parameter was recorded during *kharif* season of 2014 and 2015. In order to compute the profitability of different intercropping systems and *in-situ* moisture conservation methods over years, the net returns and benefit-cost (B:C) ratio were calculated (Maruthi Sankar *et al.,* 2012; Nema *et al.,* 2008). The gross returns (₹/ha) were computed as a product of mean yield of each treatment over years and value of the crop at each location. The net returns (₹/ha) were computed as a difference of gross returns and cost of cultivation (Rs/ha) for each treatment. The B:C ratio was derived as a ratio of gross returns and cost of cultivation for each treatment.

Results and Discussion

Effect of intercropping system and *in-situ* moisture conservation methods on crop yield

In maize based intercropping system, crop yields are expressed as maize equivalent yield (MEY). The mean MEY were calculated from the MEY of the different intercropping system during 2014 and 2015 (Table 3). The effect of different *in-situ* moisture conservation methods on maize equivalent yield (MEY) of different intercropping system for the year 2014 and 2015 are given in Fig. 1 and Table 3. The MEY was found to be lower in 2015 as compared to 2014 because of lower rainfall and more duration of dry spell during *kharif* 2015 as compared to *kharif* 2014.

Table 3 : Maize equivalent yield of different intercropping system as affected by the different *in-situ* moisture conservation methods

Treatments	Sole Maize (t/ha)			Maize + Cowpea (t/ha)			Maize + Pigeon pea (t/ha)		
	2014	2015	Mean	2014	2015	Mean	2014	2015	Mean
M1	3.2	3.05	3.125	5.15	5.02	5.085	5.45	5.3	5.375
M_2	3.45	3.27	3.36	5.48	5.29	5.385	5.8	5.62	5.71
M_3	3.4	3.2	3.3	5.44	5.23	5.335	5.75	5.56	5.655
M_4	3.7	3.5	3.6	5.7	5.4	5.55	6.0	5.75	5.875
SEM (+/-)	0.056	0.054	0.055	0.054	0.053	0.053	0.07	0.067	0.069
CD (5%)	0.181	0.173	0.176	0.171	0.166	0.168	0.235	0.221	0.227

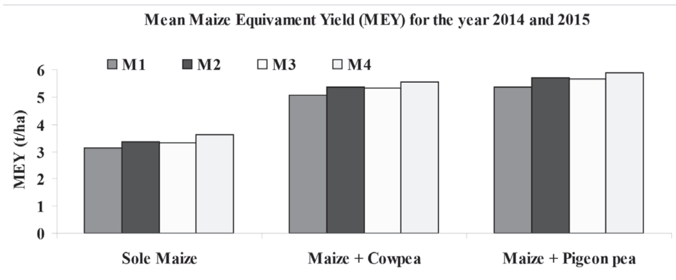

Fig. 1 : Mean maize equivalent yield of different intercropping system for the year 2014 and 2015 as affected by the different in situ moisture conservation methods

In all the intercropping system, significant difference in MEY was found between the in situ moisture conservation methods and control treatment. In sole maize, lowest mean MEY was found in control treatment with in moisture conservation method (3.125 t/ha) and highest mean MEY was found in M_4 treatment (3.6 t/ha). In maize + cowpea intercropping system, lowest mean MEY was found in case of control treatment (5.085 t/ha) and highest mean MEY was found in M_4 treatment (5.55 t/ha). Similarly, in maize + pigeonpea intercropping system, lowest mean MEY was found in case of control treatment (5.375 t/ha) and highest mean MEY was found in M_4 treatment (5.875 t/ha). There is no significant difference in MEY was found between M_2 and M_3 treatments whereas significant difference in MEY was found between M_3 and M_4 treatments; M_2 and M_4 treatments in all the intercropping system. Significant differences in MEY were also found between control (M_1) and others moisture conservation methods (M_2, M_3, M_4) in all the intercropping system. Among the maize based intercropping system, maize + pigeonpea is giving higher MEY followed by maize + cowpea in different in situ soil conservation methods. Among the different moisture conservation methods, summer ploughing and increase bund height (M_4) is giving more MEY in different maize based intercropping system.

Economics of maize based intercropping system with *in situ* moisture conservation methods

The economics of maize based intercropping system with different *in-situ* moisture conservation methods are given in the Table 4. The increase in MEY as compared to control treatment in sole maize was found to be maximum in M_4 treatment (15.6%) and minimum in M_2 treatment (6.25%). In maize + cowpea intercropping system, increase in MEY was found to be maximum in M_4 treatment (10.68%) and minimum in M_2 treatment (5.63%) whereas increase in MEY was found to be maximum in M_4 treatment (10.1%) and minimum in M_2 treatment (5.50%) in maize + pigeonpea intercropping system. The rain water use efficiency (RWUE) was found to be in the range of 4.11-4.75 in sole maize, 6.61-7.72 in maize + cowpea intercropping system and 7.0-7.70 in maize + pigeonpea intercropping system. The net return and B:C ratio was found to be highest in maize + pigeonpea intercropping system as compared to sole maize and maize + cowpea intercropping system. In different in situ soil moisture conservation methods, the net return and B:C ratio was found to be highest in M_4 treatment in all the maize based intercropping system. The net return (₹ 36000/ha) and B:C ratio (2.50) was found to be highest in maize + pigeonpea intercropping system with summer ploughing and increase bund height (M_4) followed by maize + cowpea intercropping system of net return (₹ 33000/ha) and B:C ratio (2.38) in M_4 treatment.

Table 4 : Economics of different maize based intercropping with different *in-situ* moisture conservation methods

Treatments		MEY (t/ha)	% increase in yield	RWUE (t/ha-mm)	Net returns (₹/ha)	B:C ratio
Sole maize	M_1	3.2	0	4.11	8000	1.33
	M_2	3.45	7.8	4.43	10500	1.44
	M_3	3.4	6.25	4.37	10000	1.42
	M_4	3.7	15.6	4.75	13000	1.54
Maize + Cowpea	M_1	5.15	0	6.61	27500	2.15
	M_2	5.48	6.4	7.04	30800	2.28
	M_3	5.44	5.63	6.99	30400	2.27
	M_4	5.7	10.68	7.32	33000	2.38
Maize + Pigeon pea	M_1	5.45	0	7.00	30500	2.27
	M_2	5.8	6.42	7.45	34000	2.42
	M_3	5.75	5.50	7.38	33500	2.40
	M_4	6.0	10.1	7.70	36000	2.50

This study indicated that summer ploughing with increased bund height increases the crop yield because it provides more opportunities to the absorption of water into the soil in maize based intercropping system. Similarly among the intercropping system, maize + pigeon pea intercropping system resulted higher yield, net return and B:C ratio followed by maize + cowpea intercropping system as compared to sole maize which could also be considered for recommendation for this region.

Conclusion

Based on the study conducted in the dry land situations of Phulbani districts of Odisha during 2014 and 2015, suitable intercropping system and in situ moisture conservation practices have been identified. On the basis of economics of the maize based intercropping system, the treatment of both summer ploughing and increase the bund height for *in-situ* moisture conservation resulted higher net returns and B:C ratio and could be considered for recommendation for this region. Among the intercropping system, maize + pigeon pea intercropping system resulted higher yield, net return and B:C ration followed by maize + cowpea intercropping system as compared to sole maize which could also be considered for recommendation for this region. Thus, the results and the methodology adopted in this study would be very useful to researchers, farmers, land managers, state agricultural departments, and other stakeholders not only in India but also across the world under similar climatic situations.

Acknowledgements

Authors are thankful to the AICRPDA, ICAR-CRIDA, Hyderabad for providing necessary financial and technical support under the National Innovations on Climate Resilient Agriculture (NICRA) programme.

References

Behera B, Sankar GRM, Sharma KL, Mishra A, Mohanty SK, Mishra PK, Rath BS and Grace JK. 2012. Effects of fertilizers on yield, sustainability and soil fertility under rainfed pigeon pea + rice system in subhumid oxisol soils. Commun. Soil Sci. Plant Analy., 43: 2228-2246.

Behera B, Mohanty SK and Pal AK. 2005. Integrated nutrient supply system for pigeon pea + rice intercropping system. In: Resource-conserving technologies for social upliftment, (ed. V. N. Sharda *et al.,*) 226-229.

Bhatt R, Khera KL, Arora Sanjay. 2004. Effect of tillage and mulching on yield of corn in the submontaneous rainfed region of Punjab, India. Int. J. Agric. Biol., 6: 26-28.

Gomez KA and Gomez AA. 1984. Statistical Procedures for Agricultural Research. New York: John Wiley.

Hadda MS, Khera KL, Kukal SS. 2000. Soil and water conservation practices and soil productivity in North-Western sub-montaneous tract of India: A review. Indian J. Soil Conserv., 28: 187-192.

Hadda MS, Arora Sanjay Khera KL. 2005. Evaluation of different soil and nutrient management practices on moisture conservation, growth and yield of maize in rainfed sub-montaneous tract of Punjab. J. Soil Water Conserv., 4: 101-105.

Maruthi Sankar GR, Subramanian V, Sharma KL, Mishra PK, Jyothimani S, Bhaskar K, Jawahar D, Rajeswari M, Taghavan T, Ravindra Chary G, Renuka Devi A, Gopinath KA, Venkateswarlu B and Kusuma Grace J. 2012. Modeling of interactive effects of rainfall, evaporation, soil temperature and soil fertility for sustainable productivity of sorghum + cowpea and cotton + black gram intercrops under rotation trials in a rainfed semi-arid vertisol. Commun. Soil Sci. Plant Anal., 43(5): 756-787.

Nalatwadmath SK, Rao MS, Rama Mohan and Husenappa V. 2008. Impact of inter- terrace conservation measures on sorghum yield in vertisols of semi arid tropics of south India. Indian J. Dryland Agric. Res. Dev., 23(1): 36-41.

Nema AK, Maruthi Sankar GR and Chauhan SPS. 2008. Selection of superior tillage and fertilizer practices based on rainfall and soil moisture effects on pearl millet yield under semi-arid Inceptisol. J. Irrig. Drain. Eng., 134: 361-371.

Selvaraju R and Balasubramanian TN. 2001. Effect of moisture conservation practices on water use, microclimate and productivity of intercropping in dryland vertisols. J. Agric. Phys., 1(1): 112-116.

Sur HS, Mastana PS, Hadda MS. 1992. Effect of rates and modes of mulch application on runoff, sediment and nitrogen loss on cropped and uncropped fields. Trop. Agric., 69: 319-322.

Received: September 2016; Accepted: November 2016