Int.J.Curr.Microbiol.App.Sci (2018) Special Issue-7: 1273-1279

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Special Issue-7 pp. 1273-1279**
Journal homepage: http://www.ijcmas.com

Original Research Article

Impact of Village Level Natural Resources Management (VLNRM) on Crop Yield and Economics in Semi Arid Region of Bihar to Improve Rural Livelihood and Food Securities

Anupama Kumari[1], Vijay Kumar[1]*, Surendra Prasad[1] and Brajesh Sahi[2] and Mukesh Kumar[3]

[1]Krishi Vigyan Kendra, Majhi, Saran, Bihar-841313, India
[2]Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar-848125, India
[3]Krishi Vigyan Kendra, Jalley, Darbhanga, Bihar-847302, India
**Corresponding author*

A B S T R A C T

Climatic vulnerability *viz*., drought/floods, uncertain weather events, and increasing cost of production, scarcity of water, energy & labour, diminishing farm profits are major challenges faced by the farmers under traditional cultivation or faulty management practices in Saran district of Bihar. To address these challenges, village level natural resource management (VLNRM) are being developed, adopted and promoted in the region during 2011-17 through NICRA project under the supervision of KVK, Majhi, Saran, Bihar. We evaluated yield and economics of crop under NRM practices, variety performances, and no. of farmers adopted these technologies. Medium term (2011-17) NRM through mulching (straw, plastic, natural etc.) was improved the conservation of soil moisture, regulate the soil temperature, reduced the runoff and recharged the ground water table which will reflect to expected yield and profitability of crop. Build up of black gold through incorporation of green manuring and zero tillage practices. Minimized the salinity problem in rice with the levelling /bunding and flooding. Similarly, reduced the cost of production was done through the application of adequate quantity of nutrient on the basis of soil test report. Selection of suitable variety of rice *viz*., Sahbhagi, Rajendra Bhagwati were performed well in drought condition and gave 60.0% (Sahbhagi) more yield and economics over other existing variety. Late variety of wheat i.e., DBW-14 was gave 18.0% extra yield over other tradition variety. Thus, VLNRM is a major national strategy for enhancing conservation outcomes while also seeking to improve rural livelihoods and food security.

Keywords

VLNRM, Drought, Mulching, Variety, Yield, Economics

Introduction

Village level natural resource management (VLNRM) has been widely promoted by networking project-NICRA which was launched by Indian Council of Agricultural Research in February 2011. The main aim of the project is to enhance resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration. The research on adaptation and mitigation covers crops, livestock, fisheries and natural resource management. The Saran village are mostly suffer from climatic vulnerability i.e., drought as well as floods. The introductions

of Natural Resources Management (NRM) in Affaur village for the purposes of conservation of natural resources like soil, water, biodiversity etc., simultaneously enhancing rural livelihoods and food security.

Nowadays, a combination of higher average annual temperatures and water stress (excess or deficit) can have serious implications for crop production in the tropics. Farmers need to intelligently adapt to the changing climate in order to sustain crop yields and farm income. Enhancing resilience of agriculture to climate risk is of paramount importance for protecting livelihoods of small and marginal farmers. Traditionally, technology transfer in agriculture has aimed at enhancing farm productivity. However, in the context of climate change and variability, farmers need to adapt quickly to enhance their resilience to increasing threats of climatic variability such as droughts, floods and other extreme climatic events. Implemention of different interventions by NICRA on village levels which focuses on, to enhance the resilience of Indian agriculture covering crops, livestock and fisheries to climatic variability and climate change through development and application of improved production and risk management technologies, to demonstrate site specific technology packages on farmers' fields for adapting to current climate risks, to enhance the capacity building of scientists and other stakeholders in climate resilient agricultural research and its application.

Also NICRA motivate to farmers for devolving control of natural resources to local communities improves households' access to and management of those resources, thereby improving the resource base and their benefits to village communities (Ostrom, 1990 and Lund, 2007). Since the 1990s village level NRM has been implemented across the developing world (Agrawal and Ostrom, 2001 and Persha *et al*., 2011) and continues to be an important and expanding conservation strategy (Bowler *et al*., 2010). Additionally, VLNRM provides a potential platform that other conservation strategy, such as reducing green house gas emissions from paddy field, deforestation and forest degradation, soil erosion etc. Here, we determine the impact of different VLNRM approaches in agriculture field on yield and economics of crops in Saran.

Materials and Methods

Site description

The village level interventions were initiated by the National Innovation in Climate resilient Agriculture (NICRA) which was started in 2011 under the supervision of Krishi Vigyan Kendra, Majhi, Saran, Bihar. Our selected village is Affaur covered under Saran district of Bihar. The areas are located at 25° 46' N latitude and 85° 09' E longitude and elevation of 52 m above mean sea level. The area falls in sub-tropical, semi arid agro-climatic zone of Bihar. The average rainfall of the area during 2011-17 is about 708.4 mm due to that areas fall under drought. The no of dry spell at > 10 days, > 15 days, and > 20 days during 2011-17 was 10, 2, and 3, respectively. The soils of area belong to Entisol order according to Soil Taxonomy of USDA, having clay loam in texture. Salient village information's are presented in Table 1.

Existing practices/cropping pattern

In the drought prone areas of Saran district of Bihar, paddy-wheat cropping pattern is predominant. These patterns create some problem like formation of hard pan during

puddling operation. After implementation of NICRA-technology the farmers are interested to establish more divers cropping pattern during 2011-17. Cropping pattern followed before NICRA was paddy-wheat, maize-wheat, pigeon pea- fallow, paddy-rapeseed & mustard, paddy-potato, maize – Potato. The corresponding replacement of cropping pattern after NICRA was paddy-wheat-vegetable, paddy-wheat-green gram/vegetables, paddy – maize + potato - green gram; maize-mustard-green gram/vegetables, maize-wheat-green gram; pigeon pea + turmeric; paddy-rapeseed and mustard-vegetables; paddy-potato-vegetables/green gram/sesame; maize-potato-vegetables, respectively.

Technology demonstration/resilient practices

Technology was being adopted by farmer's *viz*., mulching in vegetable/fruits (straw, plastic, natural mulch etc.), incorporation of green manuring through green gram and sesbania, sowing of rice and wheat through introduction of zero tillage and application of nutrients on the basis of soil test report. Varietal demonstration was practiced by farmers like, drought tolerant varieties of rice, heat tolerant varieties of wheat, short duration varieties of rice under timely sown & late sown condition.

Observation/data collection

The data/observation made after implementation of technology as per the requirement. The yields of crop were recorded from randomly selected plots after that calculate the average and compute per hectare yield. The economics (B: C ratio) was calculated by considering the variable as well as fixed inputs and prevailing market rates, the expenditure incurred on various inputs and operations.

Results and Discussion

Natural Resource Management (NRM) in agricultural field is best practices for conservation of soil, moisture as well as minimizes the cost of agriculture production. NRM through mulching, green manuring, zero tillage in semi arid region of Saran Bihar (Table 2) is good option for climate smart agriculture production. Paddy straw used as mulching in the brinjal crop @50 q ha^{-1}, reduced the two irrigation as compared to four irrigation in unmulched crop. The saving of no. of irrigation/moisture conservation was due to shading effect of mulching which reduces the evaporation of moisture from soil surfaces as well as regulate the soil temperature (Sharma and Kumar, 2014).

Adoption of this intervention by farmers resulted that better crop yield (275.0 q ha^{-1}), net return (Rs. 126741.0 ha^{-1}) and benefit cost ratio (4.00). Likewise, plastic mulching was done in vegetables and fruits crop, also reduced the no. of irrigation as well as maintain the sub optimal temperature for better crop yield. Natural mulching was also play an important role in similar manner just as paddy straw mulching. Farmers were also accepted and adopted the moisture retention/soil resilience by incorporating green manuring crop-Green gram and Sesbania in rice-wheat cropping system. The long term moisture retention through these practices could be due to build up of organic matter (Kumar *et al*., 2015) resulted that maximum amount of available water hold by the soil for succeeding crop.

The yield of rice after incorporation of Green gram and Sesbania was 36.0 & 39.0 q ha^{-1}, respectively, whereas, benefit cost ratio was 1.62 and 1.75, respectively. Now a day's farmers are more interested in introduction of zero tillage in rice-wheat

system because of the scarcity of labors, increasing price of fuel, increasing concentration of green house gases. Farmers of Saran district village were more interested in adaption of zero tillage in wheat than rice because of the early sowing and could get acceptable yield (42.0 q ha^{-1}) and economics (B:C ratio 2.77).

In drought condition accumulation of salts are also major threatened to agricultural production, so farmers adopted the practices- levelling /bunding and flooding for leaching of salt in paddy. These practices could also check the surface run off of water, increased moisture retention, which will reflected to maximum water use efficiency as well as nutrient use efficiency apart from that recharge of ground water. Nutrient management and reduces the cost of cultivation can be done through the soil test based nutrient application. Large no. farmers were opted this intervention and get extra income through saving of fertilizers. All these demonstrated technology has great influences on village community as well as in the whole district. Though this was not a new practice for the NICRA-village, its impact was so tremendous and remarkable. So that Department of Agriculture, Government of Bihar accepted this intervention in their technical programme.

Variety performances

Selection of variety is important consideration for drought & flood-climatic vulnerability in village. The drought, heat tolerant variety of rice and wheat, and also short duration variety of wheat were demonstrated under NICRA-village (Table 3 & Figure 1). Drought tolerant variety-Sahbhagi performed excelled among the existing varieties under drought condition. Even Hybrids variety of rice could not compete this variety under stress condition. Late onset of monsoon has become a common feature in Saran district. In such situation, short duration rice varieties like Prabhat, MTU 1010, Sahbhagi, Heera and Rajendra Bhagwati were found better in sustaining under water stress and gave considerably high return. Yield and profitability (B: C ratio) of these varieties under timely sown and late sown condition were 32.5 & 36.0 q ha^{-1}, and 1.51 & 1.53, respectively while, the short duration variety under late sown condition performed better than short duration variety under timely sown condition in terms of 10.8% extra yield as well as 1.01 times higher benefit cost ratio. Drought tolerant variety-Sahbhagi and short duration variety under timely sown condition were produced 60.0 and 80.9% higher yield as compared to traditional variety (Figure 1).

Table.1 Salient information of village-Affaur

Name of the village and district	Affaur, District- Saran
No. of households	4000
Total cultivated area (ha)	2000
Literacy rate (%) Male Female	 42 37
Area under rainfed cultivation (ha)	710
Major soil type	Clay Loam
Climatic vulnerability of the village	Drought

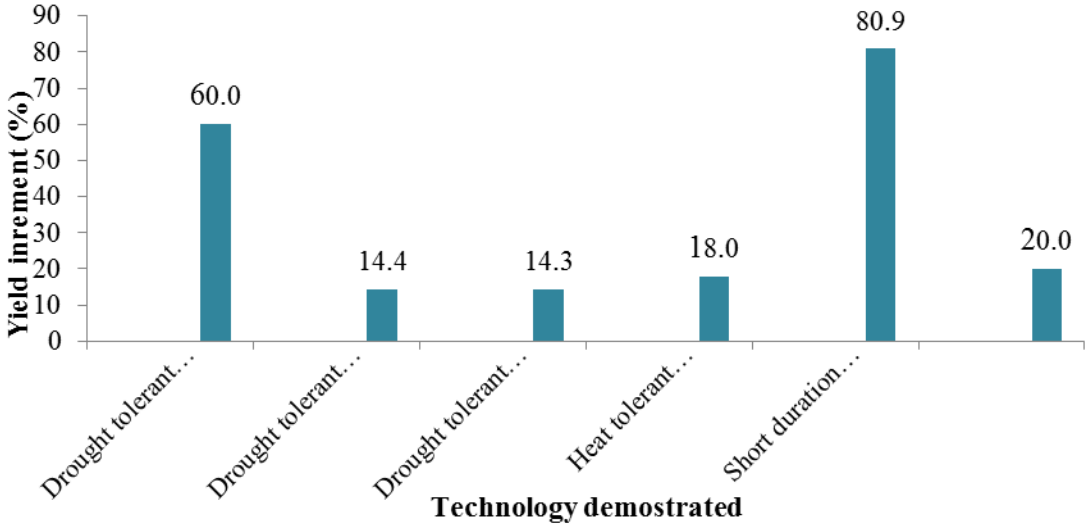
Table.2 Adoption and Impact of VLNRM practices on crop yield and economics of demonstration during 2011-17 in farmer field

Technology demonstrated	No. of farmers	Area (ha)	Yield (q ha^{-1})	Economics of demonstration (Rs. ha^{-1})			
				Gross cost	Gross return	Net return	B: C ratio
Application of paddy straw as natural mulch in brinjal	4	2.0	275.0	42259	169000.0	126741.0	4.00
Application of plastic mulch in vegetables/fruits	1	0.5	280.0	45329	200000.0	154671.0	4.41
Application of natural mulch in vegetables	4	2.0	500.0	141033	364000.0	222967.0	2.58
Application of natural mulch in guava garden	5	1.0	112.0	25670	168000.0	142330.0	6.54
Application of natural mulch in mango Garden	5	1.0	109.0	25670	163500.0	137830.0	6.37
Application of natural mulch in litchi garden	5	1.0	106.0	25670	159000.0	133330.0	6.19
Moisture retention/soil resilience by incorporating green manuring crop-Green gram	12	5.0	7.0	17102	35000.0	17898.0	2.05
Yield of succeeding rice after green gram	12	5.0	36.0	29064	47000.0	17936.0	1.62
Moisture retention by incorporating green manuring crop-Sesbania	25	13.0	0.0	0.0	0.0	0.0	0.0
Yield of succeeding rice after Sesbania	25	13.0	39.0	29064	51000.0	21936.0	1.75
Zero tillage in wheat	13	10.0	42.0	20555	57000.0	36445.0	2.77
Zero tillage in Rice	13	9.0	36.0	26000	58741.0	32741.0	2.26
Levelling /bunding and flooding for leaching of salt in paddy	12	10.0	35.0	21096	46500.0	25404.0	2.20
Soil test based nutrient application rice	300	200.0	40.0	29778	51000.0	21222.0	1.71

Table.3 Adoption and Impact of varietal demonstration on crop yield and economics during 2011-17 in farmer field

Technology demonstrated	No. of farmers	Area (ha)	Output (q ha^{-1})	Economics of demonstration (Rs. ha^{-1})			
				Gross cost	Gross return	Net return	B: C ratio
Drought tolerant rice variety-Sahbhagi	45	20.0	48.0	31167.0	64000.0	32833.0	2.05
Drought tolerant wheat variety DBW -14	144	49.0	34.6	181440.0	280600.0	99156.0	1.55
Drought tolerant rice variety Heera	45	10.0	32.0	31334.0	44000.0	12265.0	1.40
Heat tolerant (Late) variety DBW -14 (Wheat)	21	11.0	35.5	61184.0	97766.0	36580.0	1.60
Short duration varieties of rice under timely sown condition	655	139.0	32.5	279564.0	420900.0	141330.0	1.51
Short duration variety of rice under late sown condition (Late monsoon) with life saving irrigation	10	5.0	36.0	31474.0	48000.0	16525.0	1.53

Figure.1 Percent increment in crop yield under different technology demonstration during 2011-2017



Farmers procure timely-sown wheat varieties like PBW-343, but sow them late due to long duration rice variety or due to moisture stress in early *rabi* season. Thus, the crop of wheat suffers terminal heat and gives low yield. Replacing timely sown late variety PBW-343 with late sown PBW-373, HW-2045 and DBU-14 gave good crop stand and escaped terminal heat. Heat tolerant variety of wheat was obtained 18.0% higher yield over other existing variety (Figure 1).

In conclusion, we compile and explore a cross section of village-level six years' data to identify welfare benefits of village level natural resources management.

Natural resource management in terms of moisture conservation, green manuring, carbon sequestration and variety performances in drought condition attain the expected return to farmers belongs to drought climatic vulnerability in Saran district of Bihar. Thus, VLNRM provide the ecological and socioeconomic benefits of individual farmers and their communities to overcome the livelihood and food security.

Acknowledgement

The farmer's of Saran village are duly acknowledged for accept and adopt the village levels NRM-technology demonstration. The financial support of the National innovation in Climate resilient Agriculture (NICRA) is highly acknowledged

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