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Research Article

Productivity and Sustainability Enhancement of Moth Bean through Improved Technology of CFLD under Hyper Arid Partially Irrigated Zone of Rajasthan

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ABSTRACT

Field experiment on moth bean were conducted at farmers' fields in villages viz., Benisar, Bhojas and Husangsar during Kharif seasons of 2016 and Dasuri during 2019 of Bikaner district in Rajasthan state to demonstrate production potential and economic benefit of improved technologies comprising sowing method, nutrient management and chemical weed control and adoption of whole package of practices for the crop. Pendimethalin as Pre emergence at 1.0 kg a.i ha^{-1} in 500 liter of water used for effective control of the weeds during kharif season. If the weeds emerge after planting, Imazethapyr @ 37.5 g a.i. ha^{-1} as post-emergence sprayed at 30 days after sowing.

Results revealed that improved technology demonstration gave higher and sustainable yield of moth bean over the years compared to farmers practice. The mean yield recorded (739 kg ha^{-1}), which was 25.04 per cent higher as compared to farmers practice (591 kg ha^{-1}). Sustainability of moth bean yield reflects the higher sustainability yield index (0.667) and sustainability value index (0.515). Improved technology possesses incremental benefit cost ratio (5.3) over farmers practice still there was an extension gap of 148 kg ha^{-1} seed yield, indicating that along with many move front line demonstrations there is a need to disseminate the improved technologies among the farmers with effective extension methods like training and demonstrations. However, the mean technology gap of 241 kg ha^{-1} seed yield clearly indicates that research efforts are needed in realizing the potentiality of the moth bean crop under hyper arid partially irrigated zone of Rajasthan.

Keyword: *Moth bean, Sustainability yield index, Sustainability value index, Improved technology.*

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Moth bean [*Vigna aconitifolia* (Jacq.) Marechal] is a hot weather, drought resistant legume having ability to fix atmospheric nitrogen, considered important components of cropping systems produce reasonable yields with low inputs under harsh climatic and soil conditions of Rajasthan. The densely matted branches grow horizontally and have deeply notched leaflets on long leaf branches. It helps greatly in the conservation of soil, water and serves as a very efficient and suitable cover crop for checking soil erosion. Above and beyond assured production under harsh and hostile arid environment, the crop conventionally supports dietary requirement of local people to a great extent by offering a range of edible products such as dried seeds, mature and immature green pods vegetable. Traditional preparations of moth bean like *dal*, *kheech*, *papad*, *bhujia*, *mangori*, *etc*. as a part of their food habits also fulfill the nutritional need of local people well, as it contains 22–24 per cent high quality protein along with high amount of essential amino acids particularly lysine and leucine and also certain vitamins (Kumar and Singh, 2001). The production and life support systems in the hot regions are constrained by low and erratic precipitation (100-420 mm/year), extreme temperatures (45°C in peak of summer), high evapotranspiration (1500-2000 mm/year), poor soil fertility and physical conditions. This has resulted in over-exploitation of the resources causing rapid widespread land degradation and decline in productivity. There is productivity stagnation, nutrient water imbalances and increased insect-pest and disease incidence due to prolonged use of this cereal dominated system (Kumar, 2014). The production and productivity of moth bean are very low mainly due to its cultivation in resource poor lands with minimum inputs, non-synchronous maturity and indeterminate growth habit. The lower productivity of this crop is attributed to several factors *viz.*, growing the crop under moisture stress, marginal lands with very low inputs and without pest and disease management, non-availability of high yielding varieties and late sowing.

In this context, the cluster front line demonstration is an important method of transferring the latest techniques of practices to farmers by which farmers learn latest technology production factors under real farming situations on their own fields, which in turn may lead to higher adoption of improved package of practices. India government imports large quantity of pulses to fulfill domestic requirement of pulses. In this regard, to sustain this production and consumption system, the Department of Agriculture, Cooperation and Farmers Welfare had sanctioned the project "Cluster Frontline Demonstrations on *kharif* pulses from 2016'' to ICAR-ATARI, Jodhpur through National Food Security Mission. The basic strategy of the Mission is to promote and extend improved crop management practices and innovative technology, *i.e*., quality seed, micro-nutrients, soil amendments, weed management, integrated pest management, irrigation scheduling along with capacity building of farmers. This project was implemented by Krishi Vigyan Kendra, Bikaner- I of Zone-II, as grass root level organization meant for application of technology through assessment, refinement and demonstration of proven technologies under different micro farming situation in district. While, demonstrating the technologies at the farmers field, the analysis of the technology gap will help to strengthen the research. Cluster front line demonstrations conducted in cluster of ten hectares of land in order to have better impact of the demonstrated technology on the farmers and field level extension functionaries with full package of practices. Keeping in view, the present study was done to analyze the productivity and sustainability enhancement of moth bean through improved technology of CFLD under hyper arid partially irrigated zone of Rajasthan.

MATERIALS AND METHODS

The field experiments were conducted at three clusters (Cluster-I, II & III) of 25 farmers during *kharif* seasons of 2016 and one

(Cluster-I) during 2019 in four respective adopted villages (Benisar, Bhojas, Husangsar and Dasuri) of Bikaner district of Rajasthan under cluster frontline demonstration (CFLD) of National Food Security Mission (NFSM), to evaluate economic feasibility and sustainability of improved technology in moth bean. Demonstration was conducted at farmers' field having an area of 0.4 hectare each for improved and farmers practices. The package of improved technologies like line sowing, nutrient management, seed treatment and whole package were used in the demonstrations. The test variety was RMO-257 in demonstration plots. Before conducting CFLDs, a list of farmers was prepared from group meeting and specific skill training was given to the selected farmers regarding package of practices.

The improved technology demonstration included high yielding varieties, seed treatment, timely sowing, fertilizer management, plant protection measures and irrigation management. The sowing was done in the month of July. The spacing was 30x10 cm apart and the seed rate of moth bean was 12 kg ha^{-1}. The fertilizers were given as per soil testing value, however, the average recommended dose of fertilizer applied in the demonstration plots was 20 kg N, 32 kg P_2O_5 and 40 kg K_2O per hectare. The NPK fertilizers were applied through Urea, SSP & MOP respectively, at the time of sowing. Two sprays of $FeSo_4$ and $ZnSo_4$ were done to mitigate deficiency occurring during growth period of crop.

Soils under study were loamy sand in texture with a pH range of 8.1 to 8.6. The soils poor in available nitrogen, medium in phosphorous and potassium varied between 250-260, 15-19 and 225-230 kg ha^{-1}, respectively. However, the soils were deficient in micro nutrients particularly, zinc and ferrous. In demonstration plots, critical inputs in the form of quality seeds of improved varieties, micronutrient fertilization, herbicide, timely sowing, and need based of pesticides as well as irrigation time were emphasized by the KVK and comparison has been made with the existing practices (Table 1). The traditional practices were maintained in case of local check. The data output were collected from both CFLD as well as control plots and finally the extension gap, technology gap, technology index along with the incremental benefit cost ratio were calculated as suggested by Raj et al. (2013). Data were recorded at harvest from each demonstration and farmers practice plots. These recorded data were computed and analyzed for different parameters using following formulae suggested by Yadav et al. (2004).

Extension Gap= Demonstration yield - Farmers practice yield

Technology Gap= Potential yield - Demonstration yield

Technology Index= (Potential yield - Demonstration yield) / Potential yield x 100

Additional cost = Demonstration cost – Farmers practice cost

Effective gain = Additional returns – Additional cost

Additional returns = Demonstration returns – Farmers practice returns

Incremental B: C ratio = Additional returns / Additional cost

Data were further analyzed for standard deviation and coefficient of variation as per standard procedure given by Panse and Sukhatme (1961). Sustainability indices (sustainability yield index and sustainability value index) were work out using formulae given by Singh et al. (1990).

$$SYI/SVI = \frac{Y-O}{Y_{max}}$$

Where:

Y= Estimated average yield/ net return of practices over the year

O= Standard deviation

Y_{max} = Maximum yield/maximum net return.

RESULTS AND DISCUSSION

Seed yield

Seed yield of moth bean varied from 500- 980 kg ha^{-1} in improved technology and 250- 783 kg ha^{-1} in farmers practice (Table 2). Two year mean seed yield of four clusters demonstrations of moth bean was 739 kg ha^{-1} which was 25.04 per cent higher over mean yield (591 kg ha^{-1}) in farmers practices. Cluster wise per cent increase in seed yield of moth bean demonstrations over farmers practices ranged to the tune of 17.03 to 30.04 in the year 2016 and 29.82 in 2019. The higher seed yield under demonstrations could be attributed to adoption of improved technology *viz*. line sowing, use of nutrient management and weed management and ultimately enhanced moth bean productivity. Year wise variation in seed yield was observed might be due to variation in environmental conditions prevailed during that particular year. The findings confirm with the findings of Math et al. (2014), Dharwe et al. (2019) and Meena and Singh (2016).

Adoption Gap

Evaluation of findings of the study (Table 3) stated that an extension gap of 109 to 167 kg ha^{-1} was found between demonstrated technology and farmers' practice and on mean basis the extension gap was 148 kg ha^{-1}. Such gap might be attributed to the adoption of improved technology, especially high yielding varieties sown with balanced nutrition, weed management and appropriate plant protection measures in demonstrations which resulted in higher grain yield than the traditional farmers' practices the extension gap was highest. The study further exhibited a wide technology gap during different years. It was lowest (149 kg ha^{-1}) in cluster III during 2016 and the highest in cluster I (314 kg ha^{-1}) during 2019. However, there was a mean technology gap of 214 kg ha^{-1} indicating that research efforts are still needed in realizing the potentiality of the moth bean.

Similarly, the technology index for all demonstrations in the study was in accordance with technology gap. Higher technology index reflected the inadequate transfer of proven technology to growers and insufficient extension services for transfer of technology. On the basis of two years study, overall 24.6 % technological index was recorded. Hence, it can be inferred that the awareness and adoption of improved varieties with the recommended scientific package of practices have increased during the advancement of the study period. High technology index shows a poor adoption of package of practices and demonstrated technology by the farmers. The findings in front line demonstrations in accord with Patil et al. (2015), Meena and Singh (2014) and Raj et al. (2013).

Economics

Different variables like seed, fertilizers, herbicides and pesticides were considered as cash inputs for the demonstrations as well as in farmers practice. Seed yield, cost of variable inputs and sale price of produce determine the economic returns and these vary from year to year as the cost of input, labour and sale price of produce changes from time to time (Table 4). The year wise additional returns from improved technology demonstrations over farmers practice varied from ₹ 4919 ha^{-1} to ₹ 9190 ha^{-1} and average additional return of ₹ 7256 ha^{-1}. The mean additional cost of input of all the demonstrations for both years was ₹ 1404 ha^{-1}. The higher sale price of produce in spite of low production and lower additional cost of input during 2019 gave highest additional return (₹ 9190 ha^{-1}) under improved technology demonstrations over farmers practice. The higher additional returns and the effective gain obtained under demonstrations could be due to improved technology, non-monetary factors like timely operations of crop cultivation and scientific monitoring. The mean incremental benefit cost ratio (IBCR) fetched was 5.3 and it showed the positive impact of improved technology. The highest IBCR (7.1) was observed in 2019 and least (3.4) in cluster II of the year 2016. This is due to comparatively higher grain yield, less cost of input and a good sale price of produce. The results confirm with the findings of front line demonstrations on pulses by Dayanand et al. (2012), Rajni et al. (2014) and Trivedi et al. (2019).

Sustainability

A perusal of data (Table 2**)** depicted that higher standard deviation (SD) and coefficient of variation (CV) in yield were observed under farmer's practices over improved technology demonstrations for all the clusters of two years. This may be due to more variation in the yield of farmers practice from farmer to farmer and least variation in improved technology demonstrations. However, the maximum values of sustainability yield index (SYI) and sustainability value index (SVI) were found under improved technology than farmer's practices. The mean SYI and SVI over these four clusters under improved technology varied from 0.738 to 0.860 and 0.633 to 0.777 whereas, corresponding values under farmers practice were 0.673 to 0.767 and 0.464 to 0.578 respectively. Pooled data further revealed that SYI and SVI increased to the tune of 6.72 and 3.41 per cent over farmers. This shows that the improved technology is more sustainable as compared to farmers practice. The results confirm with the findings of Narolia et al. (2013) and Billore et al. (2009).

Table 1: Particulars showing the details of moth bean grown under CFLD and farmers' practice

S. No.	Particulars	Details of moth bean crop	
		Demonstration	**Farmers Practice**
1.	Variety	RMO-257	Local seed
2.	Time of sowing	First or second week of July	First or second week of July
3.	Method of sowing	The line sowing of seed with row spacing of 30 cm. after application of basal fertilizer.	Use broadcasting method of sowing after mixing with fertilizers.
4.	Seed treatment	Seed treatment with Carbendazim 50 WP 2.0 g kg^{-1} seed	No seed treatment
5.	Seed rate	12 kg ha^{-1}	20 kg ha^{-1}
6.	Nutrient management	NPKS Zn (20:40:40:25: 25) as basal and two sprays of 0.5 % $FeSo_4$ with citric acid and $ZnSo_4$ with lime were done due to deficiency occurring during growth period of crop.	Broadcasting 10 kg ha^{-1}DAP mix with seed.
7.	Weed management	Application of pre-emergence pendimethalin @ 1.00 kg ha^{-1}. If the weeds emerge after planting, Imazethapyr @ 37.5 g *a.i.* ha^{-1}.as post-emergence sprayed at 30 days after sowing.	No weed management
8.	Plant protection	Approaches of Integrated pest and disease management for the management of pest and diseases. Spray of COC @ 30 g + 2g streptocycline per 10 litre of water against bacterial blight. Spray of Quinalphos 25 E.C. @ 1.2 litre against pod borer and monocrotophos 36 SL l.0 litre ha^{-1} against white fly attack.	Injudicious use of pesticides and fungicides.

Table 2: Effect of improved technology demonstrations on seed yield, net return, SYI and SVI of moth bean

Particulars	Years and Clusters									
	2016						2019		Pooled	
	Cluster I		Cluster II		Cluster III		Cluster I			
	IT	FP	IT	FP	IT	FP	IT	FP	IT	FP
Seed yield (kg ha^{-1}) Max.	821	683	825	783	980	780	800	600	980	783
Seed yield (kg ha^{-1}) Min.	630	360	658	401	700	492	500	250	500	250
Mean yield (kg ha^{-1})	710	546	749	640	831	664	666	513	739	591
S D	51.80	85.97	40.09	88.38	67.93	65.59	75.28	77.92	85.13	101.11
CV (%)	7.29	15.75	5.35	13.81	8.17	9.87	11.30	15.19	11.52	17.12
Net return (₹ ha^{-1}) Max.	23172	18744	23343	22909	30320	22430	34200	23500	34200	23500
Net return (₹ .ha^{-1}) Min.	14570	4200	15830	5708	17720	9473	16200	2500	14570	2500
Mean Net return (₹ .ha^{-1})	18191	12558	19942	16469	23612	17219	26158	18268	21976	16128
S D	2330.9	3868.9	1804.2	3977.2	3056.7	2951.5	4516.6	4675.0	4366.89	4424.73
CV (%)	12.81	30.81	9.05	24.15	12.95	17.14	17.27	25.59	19.87	27.43
SYI	0.802	0.673	0.860	0.704	0.779	0.767	0.738	0.725	0.667	0.625
SVI	0.684	0.464	0.777	0.545	0.678	0.636	0.633	0.578	0.515	0.498

IT=Improved technology FP=Farmers practice S. D= Standard deviation

Table 3: Effect of improved technology demonstrations on seed yield and gap indices of moth bean

Year & Cluster	Yield (kg ha^{-1})		% increase over FP	Potential yield (kg ha^{-1})	Extension gap (kg ha^{-1})	Technology gap (kg ha^{-1})	Technology index (%)
	IT	FP					
2016- I	710	546	30.2	980	165	270	27.5
2016-II	749	640	17.1	980	109	231	23.5
2016-III	831	664	25.1	980	167	149	15.2
2019- I	666	513	29.9	980	153	314	32.0
Mean	739	591	25.6	980	148	241	24.6

IT=Improved technology FP=Farmers practice

Table 4: Effect of improved technology demonstrations on economics of moth bean

Year & Cluster	Cost of inputs (₹ ha^{-1})		Additional cost in IT (₹ ha^{-1})	Sale price (₹ q^{-1})	Total return (₹ ha^{-1})		Additional return in IT (₹ ha^{-1})	Effective gain (₹ ha^{-1})	IBCR
	IT	FP			IT	FP			
2016- I	13780	12000	1780	4500	31971	24558	7413	5633	4.2
2016-II	13780	12335	1445	4500	33722	28804	4919	3474	3.4
2016-III	13780	12670	1110	4500	37392	29889	7503	6393	6.8
2019- I	13800	12500	1300	6000	39958	30768	9190	7890	7.1
Mean	13785	12376	1409	4875	35761	28505	7256	5847	5.3

IT=Improved technology FP=Farmers practice

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