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Productivity and Sustainability of Green Gram as Influenced by Improved Technology of CFLD under Hyper Arid Partially Irrigated Zone of Rajasthan

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A B S T R A C T

The field experiments on green gram was carried out during four consecutive years 2016 to 2019 at farmer's field of Bikaner districts under cluster frontline demonstrations conducted by Krishi Vigyan Kendra, Bikaner to evaluate improved technology for enhancing the productivity and economics of green gram crop. Two treatments were evaluated at 25 farmers and comprised of improved technology (*i.e.* high yielding varieties, seed treatment, timely sowing, recommended fertilizer management, plant protection measures and irrigation management compared with farmer's practice. Results revealed that improved technology demonstration gave higher and sustainable yield of green gram over the years compared to farmers practice. The mean yield recorded (811 kg ha^{-1}) which was 24.39 percent higher as compared to farmers practice (652 kg/ha). Sustainability of green gram yield reflects the higher sustainability yield index (0.662) and sustainability value index (0.517) Improved technology posses higher water expense efficiency (54.0 kg ha-cm^{-1}) and incremental benefit cost ratio (7.4) over farmers practice.

Introduction

India is the major pulses producer country, accounting 25 per cent of global pulses production under 35 per cent of the total area. In a vegetarian country like India, where protein demand is fulfilled through pulses are the cheapest and concentrated source of dietary amino acids, so it is also considered as "A poor man's meat". Pulses occupy a unique position in the world of agriculture by virtue of its high protein content, which is almost double than that of cereals.

In addition to protein, pulses also contain good quality lysine, tryptophan, ascorbic acid and riboflavin. Pulses are suitable for people with diabetes, also for coronary heart disease and anemia, as they regulate the cholesterol. The presence of bioactive compounds *i.e*. phytochemicals and antioxidants, build up an anti-cancer properties in pulses. In our country, green gram is an important pulse short duration and photo insensitive crop mostly grown in *kharif* under rainfed and irrigated conditions, rotationally with cereals. It is one of the most suitability for human health, as contains 25 per cent of high digestible proteins and consumed both as whole grain as well as split *dal*. Green gram is also good for environment as the wonderful gift of nature have an ability to fix the atmospheric nitrogen (N_2), thereby helps in N cycling within the ecosystem. Besides N_2 fixation, incorporation of crop residue increases the microbial activity, restores soil properties in soil and carbon sequestration, and thus provides sustainability in crop production system. As a soil building crop green gram fixes atmospheric nitrogen through symbiotic action and also be used as green manure crop adding 34 kg N ha^{-1}.

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. Besides, harsh climatic conditions, soils of the region are coarse textured, poor in organic matter, available N and P (Singh *et al.,* 2018) and have low water holding capacity.

Furthermore, traditional methods of cultivation like use of non-descript seed with little or no use of external inputs, over use irrigation for growing the crops with broadcast methods further deteriorates the situation. Moreover, diverse problems with socio-economic and infrastructural backwardness do not allow the farmers to additional invest on the use of improved production technologies. This may be due to partial adoption of recommended package of practices by the green gram growers. Technology gap is a major problem in increasing green gram production and sustainability. So far, not much systematic effort was made to study the technological gap existing in various components of green gram cultivation.

Indian 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 a district. Keeping this in view, cluster front line demonstrations were organized in participatory mode to enhance the productivity; economic returns and sustainability with the objective analyze the yield gaps and impact of technology on sustainability in green gram cultivation on the newly recommended package of practice.

Materials and Methods

The field experiments of 0.40 ha each were conducted at 25 farmers fields in four adopted villages of Bikaner district of Rajasthan under cluster frontline demonstration (CFLD) of National Food Security Mission (NFSM) during four consecutive *kharif* seasons of 2016 to 2019, to evaluate economic feasibility and sustainability of improved technology in green gram. 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 difference between demonstration package and existing farmers practices are given in Table 1. 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 green gram was 15 kg ha^{-1}. The fertilizers were given as per soil testing value; however, the average recommended dose of fertilizer applied in the demo plots was 20 kg N, 40 kg P_2O_5, 40 kg K_2O and 25 kg S per hectare. The NPK & S fertilizers were applied through Urea, SSP, MOP & elemental S respectively, at the time of sowing. The two sprays of $FeSo_4$ and $ZnSo_4$ were done due to deficiency occurring during growth period of crop. Soils under study were loamy sand in texture with a pH range of 8.3 to 8.7. The soils poor in available nitrogen, medium in phosphorous and potassium varied between 250-260, 15-19 and 227-230 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 necessary step for the selection of site and farmers and lay out of demonstration were followed as suggested by Chaudhary (1999).

The traditional practices were maintained in case of local check. The data output were collected from both CFLD plots as well as control plot 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 blocks and farmer's practice blocks. These recorded data were computed and analyzed for different parameters using following formulae suggested by Prasad *et al.*, (1993).

Extension Gap=Demonstration yield (Di) - Farmers practice yield (Fi)
Technology Gap= Potential yield (Pi) - Demonstration yield (Di)
Technology Index= (Pi-Di)/Pi x 100

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 green gram varied from 587-1070 kg ha^{-1} in improved technology and 400-860 kg/ha in farmers practice (Table 2). Four year mean seed yield of demonstrations of green gram was 811 kg ha^{-1} which was 24.38 per cent higher over four years mean yield (652 kg/ha). Year wise per cent increase in seed yield of green gram demonstrations over farmer's practices ranged to the tune of 23.03 to 32.25. The higher seed yield under demonstrations could be attributed to adoption of improved technology and ultimately enhanced green gram productivity. Year wise variation in seed yield was observed might be due to variation in environmental conditions prevailed during that particular year. Similar finding was reported by Bhargav *et al.,* (2017) stated that improved package of practices has shown positive effect on yield potentials of different crops. Test blocks green gram higher mean water expanse efficiency (54.0 kg ha-cm^{-1}) as compared to farmers practice. This might be due to effective depth of irrigation water applied and obtained higher yields. The results corroborate the finding of Singh *et al.*, (2013) and Bhan *et al.,* (2014).

Adoption gap

Data (Table 3) revealed that adoption gap is a key factor for enhancing the productivity of green gram. Gap analysis was done by evaluating the extension gap, technology gap and technological index to measure the magnitude of adoption technology. Extension gap is a parameter to know the yield difference between the demonstrated technology and farmers practice and observed data further indicated that extension gap varied from 152 to 169 kg ha^{-1} with an average of 1.59 kg ha^{-1}. This indicated a wide gap between the demonstrated improved technology and the farmers practice.

Technology gap is a measure of difference between potential yield and yield obtained under improved technology demonstration. It has a great significance than other parameters as it indicates the constraints in implementation of technology and drawbacks in our package of practices. This also reflects the poor extension activities, which resulted in lesser adoption of improved water management technology and package of practices by the farmers.

This gap can be bridge by strengthening the extension activities and further on farm research to improve the package of practices. Technology index is dependent on technology gap and is a function expressed in per cent age. Technology index of four years of study varied from 17.5 to 42.3 per cent with an average of 32.1 per cent. The very low technology index (17.5) during the year 2016 could be due to adoption of improved technology, favorable climatic conditions, free from insect pest and disease incidence. 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) and Meena *et al.,* (2018).

Economics

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 farmer's practice varied from Rs 7604 ha^{-1} to Rs 9798 ha^{-1} and average additional return of Rs 8782 ha^{-1}. The mean additional cost of input of all the demonstrations for four years was Rs. 1200/ha.

Table.1 Comparison between demonstration packing and existing practices under green gram crop

S. No.	Particulars	Green gram Crop	
		Demonstration	**Farmers Practice**
1.	Farming situation	Irrigated	Irrigated
2.	Variety	SML-668 and MH-421	K-851 or Local seed
3.	Time of sowing	First or second week of July	First or second week of July
4.	Method of sowing	The line sowing of seed with row spacing of 30 cm. was done after application of basal fertilizer dose	Some farmers adopted line sowing with 30 cm. row spacing. However mostly farmers use broadcasting method of sowing. The fertilizers mixing with seed is a common practice in sowing.
5.	Seed treatment	Carbendazim @ 2.0 g kg^{-1} seed	No seed treatment
6.	Seed rate	15 kg ha^{-1}	20 kg ha^{-1}
7.	Fertilizer dose	NPKS Zn (20:40:40:25: 25)	NPKS Zn (56:24:00:25:00)
8.	Micronutrient	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.	$ZnSo_4$ applied with irrigation water
9.	Irrigation	First at 30 DAS and then irrigated 3 times	First at 10-15 DAS and then applied continue up to 4-5 irrigations
10.	Weed management	Application of pre-emergence herbicide 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.	Application pendimethalin @ 1.00 kg ha^{-1} as pre emergence but applied with irrigation water.
11.	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 and net return of green gram

Particulars	**Years**									
	2016		**2017**		**2018**		**2019**		**Pooled**	
	IT	**FP**	**IT**	**FP**	**IT**	**FP**	**IT**	**FP**	**IT**	**FP**
Seed yield (kg ha^{-1}) Max.	1070	860	950	800	799	630	965	760	1070	**860**
Seed yield (kg ha^{-1}) Min.	812	470	650	400	587	418	662	410	587	**400**
Mean yield (kg ha^{-1})	907	751	812	660	693	524	831	673	811	**652**
S D	70.03	122.88	82.48	103.46	36.81	60.01	75.55	84.58	102.58	**124.93**
CV (%)	7.72	16.36	10.16	15.69	5.31	11.46	9.09	12.57	12.66	**19.17**
Net return (Rs. ha^{-1}) Max.	42780	32440	32000	25500	28145	20150	43330	32120	43330	**32440**
Net return (Rs.ha^{-1}) Min.	28848	11402	17000	5500	16485	8481	24544	10420	16485	**5500**
Mean Net return (Rs.ha^{-1})	33989	26549	25084	18480	22296	14309	35012	26714	29095	**21513**
S D	3781.5	6635.4	4123.8	5173.0	2024.7	3300.4	4684.4	5244.2	6672.88	**7424.93**
CV (%)	11.13	24.99	16.44	27.99	9.08	23.06	13.38	19.63	22.93	**34.51**
SYI	0.782	0.730	0.768	0.695	0.821	0.736	0.783	0.774	0.662	**0.613**
SVI	**0.706**	**0.614**	**0.655**	**0.522**	**0.720**	**0.546**	**0.700**	**0.668**	**0.517**	**0.434**

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

Table.3 Effect of improved technology demonstrations on seed yield, water expense efficiency and gap indices of green gram

Year	Yield (kg ha^{-1})		% increase over FP	WEE (kg ha-cm^{-1})		Potential yield (kg ha^{-1})	Extension gap (kg ha^{-1})	Technology gap (kg ha^{-1})	Technology index (%)
	IT	FP		IT	FP				
2016	907	751	20.8	60.5	30.0	1100	156	193	**17.5**
2017	812	660	23.1	54.1	26.4	1200	152	388	**32.4**
2018	693	524	32.2	46.2	21.0	1200	169	507	**42.3**
2019	831	673	23.5	55.4	26.9	1300	158	469	**36.1**
Mean	**811**	**652**	**24.9**	**54.0**	**26.1**	**1200**	**159**	**389**	**32.1**

IT=Improved technology FP=Farmers practice

Table.4 Effect of improved technology demonstrations on economics of green gram

Year	Cost of inputs (Rs ha^{-1})		Additional cost in IT(Rs ha^{-1})	Sale price (Rs q^{-1})	Total return (Rs ha^{-1})		Additional return in IT (Rs ha^{-1})	Effective gain (Rs ha^{-1})	IBCR
	IT	FP			IT	FP			
2016	15000	14000	1000	5400	48989	40549	8440	7440	**8.4**
2017	15500	14500	1000	5000	40584	32980	7604	6604	**7.6**
2018	15800	14500	1300	5500	38096	28809	9287	7987	**7.1**
2019	16500	15000	1500	6200	51512	41714	9798	8298	**6.5**
Mean	**15700**	**14500**	**1200**	**5525**	**44795**	**36013**	**8782**	**7582**	**7.4**

IT=Improved technology FP=Farmers practice

The higher sale price of produce in spite of low production and lower additional cost of input during 2019 gave highest additional return (Rs 8298 ha^{-1}) under improved technology demonstrations over farmer's practice.

The mean incremental benefit cost ratio (IBCR) fetched was 7.4 and it showed the positive impact of improved technology. The highest IBCR (8.4) was observed in 2016 and least in 2019 (6.5). This is due to comparatively higher grain yield, less cost of input and a good sale price of produce (Trivedi *et al.,* 2019 and Singh *et al.,* 2012).

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 four years. This may be due to more variation in the yield of farmer's 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 years under improved technology varied from 0.768 to 0.821 and 0.655 to 0.720 whereas, corresponding values under farmers practice were 0.695 to 0.774 and 0.522 to 0.668 respectively. Pooled data further revealed that SYI and SVI increased to the tune of 9.99 and 19.12 per cent over farmers. This shows that the improved technology is more sustainable as compared to farmer's practice. Similar results have been reported by Narolia *et al.,* (2013).

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