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

M. L. Reager¹, B. S. Mitharwal¹, Upendra Kumar¹ and C. K. Dotaniya¹,²*
¹Assistant Professor, Krishi Vigyan Kendra, ²Ph.D. Research Scholar, Krishi Vigyan Kendra, Swami Keshwanand Rajasthan Agricultural University, Bikaner-334 006, Rajasthan
¹,²ICAR- Indian Institute of Soil Science, Bhopal M. P. 462038
*Corresponding Author E-mail: drmadanagro@gmail.com
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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\(_2\)O\(_5\) and 40 kg K\(_2\)O 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 \times 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 worked out using formulae given by Singh et al. (1990).

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\text{SYI/ SVI} = \frac{\text{Y-O}}{\text{Y} \times \text{O}}
\]

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 | 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 1.0 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                  | 2016 |                |                |                | 2019 |                |                | Pooled         |
|------------------------------|------|----------------|----------------|----------------|------|----------------|----------------|----------------|
|                              | IT   | FP             | IT             | FP             | IT   | FP             | IT             | IT             |
| 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 (%) |
|----------------|-----------------|--------------------|--------------------------|-------------------------|--------------------------|----------------------|
| 2016- I        | 710             | 30.2               | 980                      | 165                     | 270                      | 27.5                 |
| 2016- II       | 749             | 17.1               | 980                      | 109                     | 231                      | 23.5                 |
| 2016- III      | 831             | 25.1               | 980                      | 167                     | 149                      | 15.2                 |
| 2019- I        | 666             | 29.9               | 980                      | 153                     | 314                      | 32.0                 |
| Mean           | 739             | 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 |
|----------------|--------------------------|---------------------------------|--------------------|-----------------------|----------------------------------|--------------------------|------|
| 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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