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Impact of integrated crop management practices in chickpea on productivity, energy budgeting and employment generation in tribal belt of Rajasthan

Sunil Kumar*, Subhash Aswal, Nupur Sharma, Gitika Sharma, Anita Choudhary and Pappu Khatik

Agriculture University, Kota, Rajasthan, India

***Email:** *skumar21787@gmail.com*

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Dr. Narendra Kumar, ICAR-Indian Institute of Pulses Research, Kanpur

ABSTRACT

In the present study impact of integrated crop management (ICM) practices of chickpea were studied at 120 farmers fields which included improved variety GNG 1958, soil treatment with *Trichoderma virdae* @ 2.5 kg ha^{-1}, seed treatment with insecticide (Chlorpyrifos 20 EC), fungicide (Carboxin 37.5% + Thiram 37.5% DS) and culture (*Rhizobium* + PSB), nutrient management (N: P: K: Zn @ 20:40:45:5 kg ha^{-1}), nipping at 40-45 DAS, proper irrigation, weed management and integrated pest management by installation of bird perches and spraying of emamectin benzoate 5 SG at ETL. It is evident from results that the average yields of ICM plots that ranges from 2307-2722 kg ha^{-1} were higher over the farmers practice (FP) of 1805-2065 kg ha^{-1} during 2016-17 to 2019-20. Similarly, higher gross return (¹ 96344-137439 ha^{-1}), net return (¹ 67038-105219 ha^{-1}) and benefit cost ratio (2.29 - 3.27) was obtained with ICM plots over the FP during all the years of study. The energy input of ICM plots was 5872.88 MJ ha^{-1} which is 7.03 % lower that FP (6316.79 MJ ha^{-1}). The per hectare employment generation was higher in ICM plots (41 days) over the FP (30 days). It is concluded that by adopting ICM practices framers can obtain higher yield, net return and can save energy and generate more employment as comparison to exiting farmer's practices.

Key words: Chickpea, Employment, Energy, ICM, Net return, Productivity

INTRODUCTION

India is the largest pulses' cultivating country in the world but its share to total food grain production is only 6-7 %. Pulses possess several qualities such as being rich in protein, aid in improving soil fertility and physical structure, fitting into mixed/inter-cropping systems, crop rotations and dry farming, and providing green pods for vegetable and nutritious fodder for cattle as well. In chickpea, Rajasthan ranks second (16.64 % and 14.99 % of total area and production of country) after Madhya Pradesh. It is the second major *rabi* crop of Kota region after wheat.

Cluster front Line demonstrations (CFLDs) is a unique approach providing direct interface between researchers and farmers as scientists are directly involved in planning, execution and monitoring of the demonstrations in clusters for the technologies developed by them and get direct feedback from the farmers' field. This enables the scientists to improvise upon the research programme accordingly. In the present study an attempt has been made to examine the impact of CFLDs of integrated crop management (ICM) practices in chickpea in Baran district. The major constraints in chickpea production *i.e.* use of low yield potential varieties, less attention on INM and IPM, poor water management led to poor yields. It was found from the survey that a wide gap exists between the potential and farmers yield in chickpea which might be due to technology and extension gaps and also lack of awareness about new technology among tribes of the district, inspite of soil being fertile and with availability of irrigation facility. Keeping these points in mind CFLDs on ICM of chickpea were organized to enhance productivity, net return, horizontal spread of new variety as well as technologies, energy use efficiency and employment in tribal belt of Rajasthan.

MATERIALS AND METHODS

Site and crop management

The study was conducted at farmer's field of Kishanganj and Shahabad block of Baran district in Rajasthan state during the *rabi* season of 2016-17 to 2019-20. The Kishanganj and Shahabad block is located at 26.0982° N, 87.9450° E and 27.6441° N, 79.9447° E latitude and longitude, respectively. The study area comes under tribal belt and is situated at the South-Eastern corner of the state. The predominant soil of the zone is black soil of alluvial origin with clay loam in texture. Major cropping pattern of the area is Soybean/Blackgram/Maize-Wheat/Mustard/Gram/Coriander. Before organizing CFLDs, the KVK scientist's team had collected baseline information and soil fertility status of the area in the year 2016 and then after the demonstrations were laid out. The CFLDs were organized on farmers' field and adopted ICM practices recommended by Agriculture University, Kota (Rajasthan). The farmer practice was considered as local check in a cluster. These control plots were maintained by the farmers according to their own traditional cultivation practices. In the CFLD plots, ICM practices were adopted like treated seed of improved variety GNG 1958, optimum seed rate (80 kg ha^{-1}), 30 cm x 10 cm spacing, seed treatment with insecticide (Chlorpyrifos 20 EC @ 5 ml), fungicide (Carboxin 37.5% + Thiram 37.5% DS @ 1 g) and culture (*Rhizobium* + *PSB* @ 5 g kg^{-1} seed). Soil treatment done with *Trichoderma viride* @ 2.5 kg ha^{-1} mixing with vermicompost/FYM (50 kg ha^{-1}) and spread in the field before sowing for effective control of soil born fungus specially *Fusarium oxysporum f. sp. ciceri*. Full dose of nutrients N: P: K: Zn (@ 20:40:45:5 kg ha^{-1}) was applied as the basal dose. In CFLD plots irrigation was done 45-50 days after nipping which was approximately one week later than farmers practice. The gram pod borer was controlled by establishment of 50 bird perches and application of emamectin benzoate 5 SG @ 200g ha^{-1} at ETL level.

Observations

A total of 120 farmers were selected for conducting of CFLDs on ICM practices of chickpea. The study was conducted in experimental designs (Control-Treatment and Before-After) of social research. The yield data of demonstration plots as well as control plots were collected immediately after harvesting to assess the impact of CFLDs intervention on different parameters of chickpea. The input and output prices of commodities prevailing during the study of demonstration were taken for calculating net return and benefit cost ratio. However, structured and pre-tested interview schedule was used to elicit the information from beneficiary farmers about adoption, varietal replacement and horizontal spread of production technologies in the study area. Personal interview was also conducted with the beneficiary farmers after completion of each year. Following equations were used to assess the impact of CFLDs on the different parameters of chickpea crop (Parmar *et al*. 2017 and Wadkar *et al*. 2018).

$$\text{Impact on yield (\% change)} : \frac{\text{Yield of ICM Plot (kg ha}^{-1}\text{)} - \text{Yield of FP Plot (kg ha}^{-1}\text{)}}{\text{Yield of FP Plot (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Impact on adoption (\% change)} : \frac{\text{No. of adopters after CFLD} - \text{No. of adopters before CFLD}}{\text{No. of adopters before CFLD}} \times 100$$

The energy analysis and employment generation presented in this study compared the energy input, output and use efficiency between ICM practices and FP calculated during 2019-20. The input amount and energy requirement from sowing to transportation for each input item were determined and quantified. Generally, inputs in the chickpea field include human labour, machinery, diesel, fertilizers, irrigation water, seed, bio-inoculant and pesticides. The total dry weight of the chickpea crop was considered output, which comprised both grain and straw yield. For estimation of energy input and output (expressed in MJ ha^{-1}) for each items of input and agronomic practice equivalents were used from the published literature given in Table 1. These inputs were then multiplied by their matching energy equivalent to calculate the energy input of each item and total energy input was calculated as the sum of the energy used of all inputs.

Table 1. Energy equivalent of inputs and output in chickpea.

Particulars	Unit	Energy Equivalent (MJ unit^{-1})	References
A. Input			
1. Human labour	MJ h^{-1}	1.96	Choudhary *et al*., 2017
2. Machinery	MJ h^{-1}	62.70	Pandiaraj *et al*., 2017
3. Diesel	MJ l^{-1}	56.31	Choudhary *et al*., 2017
4. Nitrogen (N)	MJ kg^{-1}	60.6	Oren and Ozturk, 2006
5. Phosphorus (P)	MJ kg^{-1}	11.1	Oren and Ozturk, 2006
6. Potash (K)	MJ kg^{-1}	6.7	Nandan *et al*., 2020
7. Micronutrient (Zn)	MJ kg^{-1}	8.40	Argiro *et al*., 2006
8. Water for irrigation	MJ m^{-3}	1.02	Pandiaraj *et al*., 2017
9. Seed (chickpea)	MJ kg^{-1}	14.7	Elhami *et al*., 2016
10. Bio-inoculant	MJ kg^{-1}	14.5	Mihov and Tringovska, 2010
11. Insecticide	MJ kg^{-1}	184.63	Paramesh *et al*., 2019
12. Fungicide	MJ kg^{-1}	97.0	Paramesh *et al*., 2019
B. Output			
1. Seed (chickpea)	MJ kg^{-1}	14.7	Elhami *et al*., 2016
2. By product (Straw)	MJ kg^{-1}	12.50	Koocheki *et al*., 2011

The energy output from the grain and straw was estimated by multiplying the amount of production per hectare by its corresponding energy equivalent. Based on energy inputs and outputs, net energy and energy use efficiency were calculated (Lal *et al*. 2015 and Yuan and Peng 2017).

Net energy (MJ ha-1) : Energy output (MJ ha-1) - Energy input (MJ ha-1)

$$\text{Energy use efficiency: } \frac{\text{Energy output (MJ ha}^{-1}\text{)}}{\text{Energy input (MJ ha}^{-1}\text{)}}$$

RESULTS AND DISCUSSIONS

Yield and economics

A comparison of the productivity level between ICM practices and FP is shown in Table 2. It is evident from results that the average yield of four years of ICM practices plots of chickpea was higher over FP (control plot). This showed significant increase in the mean yield of chickpea under ICM plots over the FP by 27.81, 28.96, 30.99 and 40.31 % during 2016-17, 2017-18, 2018-19 and 2019-20, respectively. The trend of yield increment of ICM plots over the district yield was also similar. Economics evaluation of the ICM CFLDs revealed that its adoption involved an additional cost of 4.44 to 8.40 % over farmer's practice. The ICM demonstrations recorded higher gross return (₹ 96344-137439), net return (₹ 67038-105219), benefit: cost ratio (2.29-3.27) as compared to FP during all the years of study.

The main reasons of the high yield of chickpea ICM plots were the use of improved variety (GNG 1958), optimum seed rate, plant geometry, seed and soil treatment, nutrient management, nipping, water management and IPM practices. The reason of low yield from FP might be due to higher seed rate, dense planting and early irrigation (35-40 DAS) which gives excessive growth to crop and poor yield attributes. In study area incidence of *Fusarium oxysporum f. sp. ciceri* observed which was not managed effectively in FP plots whereas, in ICM plots seed treatment and soil treatment practiced which gave insect-pest and disease free environment to the young seedling. The nipping (40-45 DAS) enhance branching and fruiting. In addition to these, need based nutrient supply and IPM also contributed to higher yield in ICM plots. The grain yield as well as straw yield is more in ICM plots, therefore net return was also more. Various research workers have conclusively proved that ICM practices gave more yield and benefit cost ratio. Tomar (2010) and Singh *et al*. (2014) reported higher net return and benefit: cost ratio with improved production technologies over the FP in chickpea crop. Such results with respect to yield and economics were reported earlier by Dudhade *et al*., 2009, Poonia and Pithia, 2011, Parmar *et al*., 2017 and Wadkar *et al*., 2018. Singh *et al*. (2020) also reported that improved production techniques are more beneficial as compared to existing farmer's practices in chickpea.

Cost of cultivation and output

The cost of cultivation of ICM demonstration plots (Table 4) was ₹ 32220 ha^{-1} whereas in FP plots it was ₹ 29513 ha^{-1} during 2019-20. In ICM plots, the highest cost incurred on irrigation (18.31%) followed by seed (14.90%), fertilizers (13.56%), harvesting (12.57%), threshing (10.94%), field preparation (7.76%), nipping (6.98%), sowing (3.88), seed and soil treatment (4.42%), insecticide (3.57%) and transportation (3.10%). In case of FP plots, the highest cost incurred on seed (22.36%) followed by irrigation (19.99%), harvesting (13.72%), threshing (11.26%), fertilizers (7.83%), field preparation (7.76%), insecticide (4.48%), sowing (4.24) and transportation (3.39%). It is evident from Table 3 that the overall 4.44 to 8.40% higher cost incurred on

Table 2. Impact integrated crop management practices on yield of chickpea

Year	ICM demo. area (ha)	No. of ICM demo.	Average yield (kg ha^{-1})			Impact (% Change)	
			District (kg ha^{-1})	FP (kg ha^{-1})	ICM (kg ha^{-1})	Over FP	Over District
2016-17	20	50	17.73	18.05	23.07	27.81	30.12
2017-18	50	125	18.43	18.82	24.27	28.96	31.69
2018-19	30	75	20.52	20.65	27.05	30.99	31.82
2019-20	20	50	18.92	19.40	27.22	40.31	43.87

Table 3. Impact of integrated crop management practices on economics of chickpea

Year	Economics of FP				Economics of ICM			
	Cost (₹ ha^{-1})	Gross Return (₹ ha^{-1})	Net Return (₹ ha^{-1})	B:C	Cost (₹ ha^{-1})	Gross Return (₹ ha^{-1})	Net Return (₹ ha^{-1})	B:C
2016-17	28005	75273	47268	1.69	29306	96344	67038	2.29
2017-18	28609	86012	57403	2.01	29917	111048	81131	2.71
2018-19	29310	98919	69609	2.37	31982	129684	97702	3.05
2019-20	29513	97878	68365	2.32	32220	137439	105219	3.27

Table 4. Impact of ICM practices on cost of cultivation and output of chickpea (2019-20)

Particulars	ICM cost (₹ ha⁻¹)	Remarks	FP cost (₹ ha⁻¹)	Remarks
A. Input				
1. Field preparation	2500 (7.76)	Harrowing-1, Cultivator-1 (₹1250 ha⁻¹)	3750 (12.71)	Harrowing-2, Cultivator-1 (₹ 1250 ha⁻¹)
2. Seed	4800 (14.90)	Seed rate 80 kg ha⁻¹ ; Seed cost @ ₹ 60 kg⁻¹	6600 (22.36)	Seed rate 110 kg ha⁻¹
3. Seed & soil treatment	1200 (3.72)	Seed: Insecticide: Chlorpyrifos 20 EC (₹ 400), Fungicide: Carboxin 37.5% + Thiram 37.5% DS (₹ 225) & Culture: Rhizobium + PSB (₹ 200) Soil: *Trichoderma viride* 2.5 kg ha⁻¹ @ (₹ 375)	00 (00)	NA
	225 (0.70)	Seed & soil treatment charge (1 man day)	00 (00)	NA
4. Sowing	1250 (3.88)	(₹ 1250 ha⁻¹)	1250 (4.24)	(₹ 1250 ha⁻¹)
5. Fertilizers	4145 (12.86)	N:P:K:Zn @ 20:40:45:5 kg ha⁻¹ {DAP: ₹ 2088+Urea: ₹ 59+MOP: ₹ 720+ Zinc Sulphate (Mono): ₹ 1275}	2088 (7.07)	N:P @ 18:46 kg ha⁻¹ (DAP: ₹ 2088)
	225 (0.70)	Fertilizers application charge (1 man day)	225 (0.76)	Fertilizers application charge (1 man day)
6. Irrigation charge	5000 (15.52)	₹ 2500 per irrigation (Paleva & one irrigation at 45-50 DAS)	5000 (16.94)	(Paleva & one irrigation at 30-40 DAS)
	900 (2.79)	Irrigation application charge (4 man day)	900 (3.05)	Irrigation application charge (4 man day)
7. Nipping	2250 (6.98)	10 man day	00 (00)	NA
8. Insecticide	700 (2.17)	Emamectin benzoate 5 SG @200g ha⁻¹	875 (2.96)	Chlorpyriphos 20 EC 2.0 l ha⁻¹
	450 (1.40)	Insecticide application charge (2 man day)	450 (1.52)	Insecticides application charge (2 man day)
9. Harvesting	4050 (12.57)	18 man day	4050 (13.72)	18 man day
10. Threshing	2400 (7.45)	3 hrs ha⁻¹ @ ₹ 800 hr⁻¹	2200 (7.45)	2.75 hrs ha⁻¹ @ ₹ 800 hr⁻¹
	1125 (3.49)	Threshing labour (5 man day)	1125 (3.81)	Threshing labour (5 man day)
11. Transportation charge	1000 (3.10)	-	1000 (3.39)	-
Total cost (₹)	32220		29513	
B. Output				
1. Main product (Grain)	132698 (96.55)	2722 kg ha⁻¹ (@ ₹48.75 kg⁻¹)	94575 (96.63)	1940 kg ha-1 (@ ₹48.75 kg⁻¹)
2. By product (Straw)	4441 (3.23)	4441 kg ha⁻¹ (@ ₹1.0 kg⁻¹)	3303 (3.370	3235 kg ha⁻¹ (@ ₹1.0 kg⁻¹)
3. Green leaves (Nipping)	300 (0.22)	50 kg ha⁻¹ (@ ₹6.0 kg⁻¹)	00 (00)	NA
Total	137439	7122 kg ha⁻¹	97878	5135 kg ha⁻¹

Figures in parentheses indicate percentage   Source: Field survey of 2019-20

cultivation of chickpea under ICM practices over the FP during 2016-17 to 2019-20. The total output from ICM plots was 7122 kg ha^{-1}(value of ¹ 137006 ha^{-1}) which includes grain, straw and green leaves (nipping) yield whereas the FP plots it was only 5135 kg ha^{-1} yield (value of ¹ 95860 ha^{-1}). It concludes from the data that chickpea cultivation cost incurred in order of irrigation> seed> fertilizers> harvesting and threshing>field preparation> nipping>sowing> seed and soil treatment> insecticide> transportation while in FP spend in order of seed> irrigation> harvesting and threshing> fertilizers>field preparation> insecticide> sowing >transportation. During 2019-20 the 8.40 % higher cost of ICM practices over the FP was might be due to more cost incurred on seed and soil treatment and nipping operation which was not practiced in FP along with that more cost spent on fertilizers too. One extra tillage operation and higher seed rate in FP plots narrows the cost of cultivation difference between both the treatments though additional expenditure occurred on seed and soil treatment, nutrient management, nipping etc. in ICM plots. Verma *et al*. (2016) found that out of total cost of chickpea 13.83% and 13.79% spend on human labour and seed, respectively. Similarly Grover (2010) also reported that labour, machine; seed and plant protection material contributes more than 50 % of total cost of cultivation of chickpea.

Adoption of ICM practices

Data on adoption of chickpea ICM practices by the farmers are presented in Table 5. It was found that a number of adopters for improved variety (GNG 1958) and recommended seed rate (80 kg ha^{-1}) of chickpea were nil before ICM demonstrations, which reached up to 100% after the demonstrations. A very good adoption was also observed in the case of seed and soil treatment, spacing and nipping as an increase in the percentage of adopters from 10.00 to 99.33, 6.67 to 86.67, 13.33 to 92.50 and 10.83 to 94.17 %, respectively. The number of adopters of application of N: P: K: Zn (20:40:45:5 kg ha^{-1}) and insect management by using IPM model were also increased significantly during pre and post-demonstrations period from 35.83 to 90.83% and from 44.17 to 97.50 %, respectively. Number of adopters for time of irrigation application was 38.33% before demonstrations, which increased up to 96.67 % after CFLDs. In this line, significant difference was observed between the adoption of ICM CFLDs beneficiary farmers and non-beneficiary farmers towards chickpea production technology. These results are in close conformity with the findings recorded in the same crop (Sahare *et al*. 2018 and Bhargav *et al*. 2017).

Horizontal spread variety

The CFLDs are proven extension intervention for changing existing or traditional practice of farmers. It was found from data depicted in Table 6 that the previously grown varieties of chickpea such as BG 256, GNG 469, GNG 1581 and *Pratap Chana* 1 were replaced by improved variety GNG 1958 on a large scale in adopted clusters. The variety GNG 1958 was introduced for the first time in the district due to its unique traits like bold seed, medium duration with high yield potential (2680 kg ha^{-1}) which is suitable for normal sown irrigated conditions though these demonstrations. The 20 ha area demonstrations were conducted during 2016-17. There was a significant increase in area from 20.0 (1st year) to 42267 ha under GNG 1958 variety which accounts 47.27% of total chickpea area of the district in 2019-20. Reasons for the initial expansion may be the agronomical attributes such as high yielding nature, bold seed and medium duration of the introduced cultivar. In starting two years farmers faced the problem of splitting of grains during threshing and marketing due to extra boldness over the prevailing varieties. In subsequent years, this was taken care of by adopting minor modifications in threshing machine and by threshing at higher moisture. The high yields of variety also increased its area of cultivation that solved relatable marketing issues. Thus, farmers continued to adopt it on large scale for succeeding years. The replacement of local varieties with improved varieties of chickpea due to ICM has also been reported by Poonia and Pithia 2011, Kothyari *et al*. 2018 and Wadkar *et al*. 2018).

Table 6. Impact of integrated crop management practices on horizontal spread of GNG 1958 variety of chickpea in the district

Year	Area (ha) of chickpea in district	Area (ha) of GNG 1958 after ICM demonstration	% share of GNG 1958 after ICM demonstration
2016-17	14059	20	0.14
2017-18	71017	341	0.48
2018-19	37642	4850	12.88
2019-20	89422	42267	47.27

Energy budgeting and employment generation

The energy input of ICM demonstrations was 5872.88 MJ ha^{-1} which is 7.03 % lower than FP plots (6316.79 MJ ha^{-1}). The highest energy input share of ICM plots was consumed by diesel (28.05%) followed by nitrogen (20.64%), seed (20.02%), machinery (10.41%), phosphorus (7.56%), potash (5.13%), irrigation (2.08), insecticide (1.89 %), human labour (1.37%), fungicide (1.32), bio inoculant (0.81%) and micronutrient (0.72%). In case of FP plots, 72.28 % of total energy was spent on diesel, seed and nitrogen

Table 5. Impact of integrated crop management practices on adoption of chickpea production technologies

Technology	Number of Adopters (N=120)		Change in No. of adopters	Impact (% Change)
	Before ICM	After ICM		
Improved variety: GNG 1958; Seed rate @ 80 kg ha^{-1}	0 (00)	120 (100)	+120	-
Seed treatment: Insecticide: Chlorpyrifos 20 EC@ 5 ml, Fungicide: Carboxin 37.5% + Thiram 37.5% DS@1 g & Culture: Rhizobium + PSB @ 5 g kg^{-1} seed	12 (10.00)	112 (93.33)	+100	833
Soil treatment: *Trichoderma viride @ 2.5 kg ha^{-1}*	8 (6.67)	104 (86.67)	+96	1200
Spacing: 30cm × 10cm	16 (13.33)	111 (92.50)	+95	594
Nutrient management: N:P:K:Zn @ 20:40:45:5 kg ha^{-1}	43 (35.83)	109 (90.83)	+66	153
Nipping at 40-45 DAS	13 (10.83)	113 (94.17)	+100	769
Irrigation at 45-50 DAS	46 (38.33)	116 (96.67)	+70	152
Insect management: Emamectin benzoate 5 SG @ 200g + 50 bird perches ha^{-1}	53 (44.17)	117 (97.50)	+64	121

Figures in parentheses indicate percentage Source: Field survey of 2019-20

Table 7. Impact of ICM practices on total energy input, output, net energy, energy use efficiency and employment generation.

Particulars	ICM		FP	
	Quantity per unit area (ha)	Total energy equivalents (MJ ha-1)	Quantity unit^{-1} area (ha)	Total energy equivalents (MJ ha^{-1})
A. Inputs				
Human labour	41	80.36 (1.37)	30	58.8 (0.93)
Machinery	9.75	611.33 (10.41)	11	689.7 (10.92)
Diesel	29.25	1647.07 (28.05)	33	1858.23 (29.42)
Nitrogen (N)	20	1212.00 (20.64)	18	1090.8 (17.26)
Phosphorus (P)	40	444.00 (7.56)	46	510.6 (8.08)
Potash (K)	45	301.50 (5.13)	00	0 (0.00)
Micronutrient (Zn)	5	42.00 (0.72)	00	0 (0.00)
Water for irrigation	120	122.40 (2.08)	120	122.4 (1.94)
Seed	80	1176.00 (20.02)	110	1617 (25.60)
Bio-inoculant	3.30	47.85 (0.81)	00	0 (0.00)
Insecticide	0.60	110.78 (1.89)	2.0	369.26 (5.85)
Fungicide	0.80	77.60 (1.32)	00	0 (0.00)
Total	-	5872.88 (100)	-	6316.79 (100)
B. Output				
Seed (chickpea)	2722	40013.4	1900	27930.0
By product (Straw)	4350	54375.0	3235	40437.5
Total	-	94388.4	-	68367.5
C. Net energy (MJ ha^{-1})	-	88515.5	-	62050.7
D. Energy use efficiency	-	16.07	-	10.82
E. Employment (Days)	-	41	-	30

Figures in parentheses indicate percentage Source: Field survey of 2019-20

only. It is evident from Table 6 that the total energy output from ICM plots was 94388.40 MJ ha^{-1}which includes grain and straw yield whereas, the FP plots it was only 68367.5 MJ ha^{-1}. Similar trend was observed in net energy and energy use efficiency also. It concludes from the data that in FP plots, chickpea energy spend in order of diesel> seed> nitrogen>machinery> phosphorus> insecticides> irrigation> labour. The higher input energy consumed in FP may be due to more energy consumed on seed, machinery, diesel and insecticide which was lower in ICM practices. One extra tillage operation, higher seed rate and indiscriminate use of insecticide increased total energy input. The total employment per hectare was higher in ICM plots (41 man days ha^{-1}) over the FP (30 days ha^{-1}). This might be due to more labour engaged in nipping and seed treatment operation in ICM plots. Salami and Ahmadi (2010) recorded that total energy consumed in various farm operations during chickpea production was 5880 MJ ha^{-1}. Diesel energy consumed 37.9% of total energy, followed by chemical fertiliser 29.6% during production period. Diesel energy was mainly consumed for land preparation, other agricultural practices and transportation. The energy inputs in the production of chickpea have been in order of fuel energy, chemical fertilizers energy, seed energy, machinery energy, farmyard manure energy, human labour energy and chemicals energy inputs (Elhami *et al.* 2016, Baran and Gokdogan 2017 and Patil *et al*. 2014).

CONCLUSION

Chickpea is a potential *rabi* pulse crop of Baran district of Rajasthan but its productivity is meagre. It is found from the study that a wide gap exists between the potential and farmers yield in chickpea which is due to technology and extension gaps relating to lack of awareness about new technologies among the tribes of the district. Higher yield and economics was recorded in ICM plots over the years compared to farmer's practices (local check) due to increased knowledge and adoption of ICM practices. The ICM practices *viz*. use of treated seed of improved variety GNG 1958, optimum seed rate, spacing and seed treatment with insecticide (Chlorpyrifos 20 EC), fungicide (Carboxin 37.5% + Thiram 37.5% DS) and culture (Rhizobium + PSB) were adopted. The soil born fungus especially *Fusarium oxysporum f. sp. ciceri* was effectively controlled by soil treatment with *Trichoderma viride*. The full dose of nutrient N: P: K: Zn (20:40:45:5 kg ha^{-1}) supplies as basal dose was good for the profuse branching nipping (40-45 DAS) done before first irrigation. The gram pod borer was effectively controlled by establishment of 50 bird perches ha^{-1} and spraying of emamectin benzoate 5 SG at ETL level.

Hence, it is concluded that by adopting ICM practices framers can obtain higher yield, can save energy, generate more employment and extract better economics in comparison to prevailing farmers practice.

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