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Energy utilization pattern of chick pea under sprinkler irrigation system in Mungeli region of Chhattisgarh plain

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Abstract
A study was conducted to determine the energy requirement of sprinkler irrigation for Chick Pea cultivation in Mungeli district of Chhattisgarh Plain. The properties such as water resource, pumping unit, systems equipments, operation pressure, sprinkler's spacing of the sprinkler systems were investigated and determined with regards to crop. The present study was planned to conduct research each five farmers in 12 different-villages of three blocks of Mungeli district when considered their water resources and pumping units. The research was conducted on totally 60 sprinkler systems. In study, diesel fuel or electric energy, equipment manufacture energy and labour energy consumption of the sprinkler systems were determined. In study, electric energy or diesel fuel, equipment manufacture energy and labour energy consumption of the sprinkler systems were determined. Input and output energy, specific energy and energy ratio of sprinkler irrigation systems were calculated at farmers filed in district. The results revealed that the input energy, output energy, specific energy and output- input energy ratio (energy efficiency) in sprinkler irrigation for production of chickpea in Mungeli district were found to be 12538.25 (MJ ha^{-1}), 30142.5(MJ ha^{-1}), 0.77 (MJ kg^{-1}), 2.4 respectively.

Keywords: Sprinkler, Mungeli, input –out energy, specific energy, energy ratio

Introduction
Energy is one of the most important elements in agricultural production. Developing nations have limited resources and exponentially increasing populations. Increases in agricultural production will be necessary, requiring increases in arable land; On the other hand limited supply of arable land has led to intensive use of energy inputs and natural resources in agriculture; so, the farmers use their resources in excess and inefficiently, specially, when these are priced low or free or are available in plenty. Rational and effective use of energy in agriculture is one of the principal requirements for sustainable development; it will minimize environmental problems, prevent destruction of natural resources, and promote sustainable agriculture as an economical production system (Rafiee *et al*., 2010) [8]. The input and output of energy are two important factors for specifying the energetic and ecological efficiency of crop production. The energy analysis is important to ascertain more efficient and environment friendly production systems (Schroll, 1994; Ozkan *et al*., 2004) [9, 7]. Energy efficiency improvement is the key to sustainable energy management; for enhancing the energy efficiency it must be attempted to increase the production yield or to conserve the energy input without affecting the production yield (Singh *et al*., 2004) [10].
Efficient use of energy especially in agriculture is one of the vital important issues in most countries. Today's agricultural production relies greatly on the consumption of non-renewable energies such as fossil fuel (Duran Yavuz, 2014) [2]. Energy Audit attempts to balance the total energy inputs with its use and serves to identify all the energy streams in the systems and quantifies energy usages according to its discrete function. Energy Audit helps in energy cost optimization, water control, safety aspects and suggests the methods to improve the operating & maintenance practices of the system. The energy used for sprinkler irrigation is categorized into two groups which are direct and indirect energy. The direct sources of energy are those which release the energy directly like human, animal, diesel and electricity, power tiller, and tractor. Indirect energy, on the other hand, represents the energy used for the manufacture of equipment (pump, pipes, sprinkler and additional parts etc.,) constructing the sprinkler irrigation systems.

In traditional method of time due to lack of accessibility machinery and mechanized practices, the farmers uses low energy inputs into their farms and were getting lower yields from their farm. A great amount of water used for irrigation in the Mungeli region is used for chick pea production and there is an excessive water use. This situation increases energy expenses and handicaps the efficient use of insufficient water sources, and incapacitates the irrigation of larger areas through these insufficient water sources and prevents the benefit of more producers. Excessive water use causes both extravagance of insufficient water sources and more energy supply to carry the water into the area which is going to be irrigated and to apply water within the area.

The results of many conducted researches have shown that non-renewable energy sources such as fossil energy are highly used in agriculture, and irrigation needs highest energy in arid areas when comparing with other agriculture operations (Mittal *et al*., 1985; Mrini *et al*., 2001) [5, 6]. Mrini *et al*. (2001) [6] reported that 50% of energy in the field is consumed by sprinkler irrigation used in sugarcane production in Morocco. Mittal and Dhawan (1989) [4] studied energy use for different surface irrigation systems, including the basin, flow and furrow irrigation. Authors reported that irrigation operation required about 35-50% of total energy input in growing field crops under different irrigation practices. Singh *et al.* (2002) [11] found that irrigation always consumed the largest proportion of on-farm energy in their case studies of agricultural production in India’s arid zone. Sprinkler systems have the highest energy cost, with an estimated requirement of up to 162.6 GJ ha^{-1} $year^{-1}$ when supplied by groundwater with a 100 m lift (Smerdon and Hiller, 1985) [12].

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Materials and Methods

The present study was conducted in newly formed Mungeli district of Chhattisgarh plain which is situated between 22.06^0 N latitude and 81.68^0E longitude. The average altitude above sea level is 287m.Here farmers are using all possible modern technology to enhance their crop yield. For collecting information on sprinkler irrigation system technologies, the field surveys were conducted in the rural areas of Mungeli belonging to the different agro- climatic zones of Chhattisgarh state. The study was conducted at Different sprinkler irrigation of Chhattisgarh on the basis of agro-climatic zone. Out of 27 districts of Chhattisgarh, one district was randomly selected. In which three blocks selected Mungeli district. Mungeli block, Pathariya block and Lormi and each block selected in four villages were identified for the purpose of survey. The average temperatures of irrigation season within the plant growth period in the district according to the long terms records range from 7.8 and 35 ˚C. The maximum and minimum relative humidity during the crop period was 19 to 96% respectively. Both ground water and surface water sources are used in the region. The surface water source is canals and stream. Ground water sources mostly used in tubes wells for this area.

First of all, examinations and observations in sprinkler irrigation system were conducted in farmer’s field of the district. The present study was planned to conduct study on each five farmers in 12 different-villages of three blocks (Mungeli, Lormi and Pathariya) of Mungeli district when considered their water resources and pumping units. The study was conducted on 60 sprinkler systems at farmer’s field for examining. The technical information related to the power resource, pump type, main and lateral lines and sprinkler in the portable sprinkler systems; and correlated operational and technical data in the planned sprinkler systems such as main line length, lateral length, number and spacing of lateral lines, number and spacing of sprinkler**,** average operation pressure and flow rate, lateral operating duration and number of irrigations were collected.

The energy requirement for chick production was classified as direct and indirect as well as renewable and nonrenewable energy forms. Direct energy inputs include those quantities that are consumed during the crop production period. The actual energy contained in diesel fuel, electricity and human labour is characterized as direct energy inputs. Indirect energy included energy embodied in seeds, farmyard manure, irrigation water, chemical fertilizers and chemicals; also the energy consumed by machinery is classified as indirect energy. On the other hand, the nonrenewable energy sources include diesel, chemicals, chemical fertilizers, electricity and machinery, while renewable energy consists of human labour, seeds and farmyard manure. Energy obtained from sunlight was not quantified (Khan *et al.,* 2009) [13].

Irrigation operation require energy for constructing the water supply source, providing the conveyance works, installing the field irrigation system on the farms, and operating and maintaining the system. Energy consumed in irrigation operations can be classified in both direct and indirect forms. Direct energy of irrigation includes energy that is consumed for pumping and operating the farm irrigation system; it is used mostly in the forms of electricity, diesel fuel and human labour. On the other hand, indirect energy of irrigation consist of the energy consumed for manufacturing the materials for the dams, canals, pipes, pumps, and equipment as well as the energy for constructing the works and building the on farm irrigation system (Khan *et al*., 2009) [13]. In this study both the direct and the indirect energy uses in irrigation operation had considered to evaluate the full environmental footprint. For investigating the indirect energy of irrigation the coefficient of 1.02 MJ per unit of water (m^3), supplied from a given source, was used; so it was considered to be the same for all the farms in a given setting. The direct energy of irrigation was considered by calculating the energy equivalent of diesel fuel, electricity and human labour used in irrigation operations.

The sources of energy involved in crop production were direct energy and indirect energy and are described below:

Evaluation of Manual Energy

Manual energy (E_m) expended was determined using the following formula:

$$E_m = 1.96 \times N_m \times T_m \quad \ldots (1)$$

Where, N_m = Number of labor spent on a farm activity

T_m = Useful time spent by a labor on a farm activity, h

Table 1 shows the energy coefficients used in the calculations. Human energy is required for all operations. All other factors affecting manual energy were neglected for a man hours 1.96 MJ/man-h and for women hour 1.57 MJ/women-h was taken.

Evaluation of Mechanical Energy

The use of mechanical energy on the farms comprised small machinery, tractor and diesel engines. The tractor was used for mobile operations like field preparation, sowing and threshing. The hours of use of tractors and diesel engine per hectare with their horsepower rating were converted into fuel consumed in a particular operation. Ultimately diesel energy was calculated by multiplication of fuel consumed (l/ha) and energy equivalent coefficient of diesel (56.31 MJ/l).

$$E_f = 56.31 \times D \quad \ldots (2)$$

Where, 56.31 = unit energy value of diesel, MJL^{-1}

D= amount of diesel consumed, L D

Evaluation of Electricity input energy

Electricity input (Kwh ha^{-1}) = pump power ×Working hour × Energy equivalent.

$$Pump\ power = \frac{flow\ rate\ (lps) \times total\ head\ (m)}{102 \times pump\ efficiency (\%) \times derating (\%)} \quad \ldots (3)$$

Total head at the pump includes suction lift, static lift, pressure delivered and friction losses. Based on the manufacturer's specifications a pump efficiency of 80% and derating of 80% for electric motor were used for the calculations.

Evaluation of Machinery of implement energy

Machinery usage for an activity (kg ha^{-1})

$$\frac{\text{Equivalent Energy (MJ)} \times \text{Weight of implement (kg)}}{\text{Useful life of machinery (yr)} \times \text{Working hours per year (h)}} \quad \ldots (4)$$

The useful life of agricultural machines and tractors has been considered as suggested by Michal and Ojha (1996) [3].

Evaluation of Seed energy

The quantity of seed used in kilograms in a given area was recorded and converted into per hectare basis for chickpea crop. The quantity of seed used per hectare was multiplied by energy equivalent coefficient with their respective crops and thus total energy applied in the field through seed was calculated in MJ/ha.

Table 1: Equivalents for Direct and Indirect Source of Energy

S. No.	Particulars	Units	Equivalent energy (MJ)
1.	Adult man	Man-hour	1.96
2	Adult woman	Woman-hour	1.57
3.	Diesel	Litre	56.31
4.	Electricity	KW-hour	11.93
5.	Chemical fertilizer		
(i)	Nitrogen	Kg	60.60
(ii)	P_2O_5	Kg	11.10
(iii)	K_2O	Kg	6.70
(iv)	FYM	Kg	0.3
6.	Pulse crops such as: moong, lentil, arhar, sobean, peas, beans etc.	kg (dry mass)	14.7
7.	Straw, vines	kg (dry mass)	12.50
8.	Steel Wood	Kg Kg	62.7 30
9.	Water for irrigation	m^3	0.63
10.	Machinery		
(i)	Electric motor	Kg	64.80
(ii)	Engines	Kg	68.20
(iii)	Farm Machinery	Kg	62.70

Evaluation of Fertilizer energy

The quantities of fertilizer used were converted in terms of nitrogen, phosphorus, and potash content and was further multiplied by energy equivalent coefficient and energy applied through fertilizer was calculated in MJ/ha.

Energy Indices

Energy efficiency and specific energy. Energy use efficiency (energy ratio), specific energy (A. Alipour *et al.* 2012) [1], were calculated, as they are shown in Equations.

$$\text{Energy efficiency} = \frac{\text{Total energy output (MJ/ha)}}{\text{Total energy intput (MJ/ha)}} \quad \ldots (5)$$

$$\text{Specific energy} = \frac{\text{Total energy input (MJ/ha)}}{\text{Grain yield (kg/ha)}} \quad \ldots (6)$$

Result and Discussion

Energy is one of the most considerations for irrigation. The energy required for installation and operation of higher water efficient irrigation systems is significantly higher than traditional systems. Efficient use of both water and energy resources is vital in terms of productivity of agriculture as well as for environmental sustainability. The energy intensive irrigation systems need to be designed and managed in such a way that delivers maximum water and energy productivity while optimizing economic returns. The inputs used for different operations in chick pea and output obtained in terms of yield were used for calculating energetic of systems. About 29.08 percent energy is required for irrigation through portable sprinkler systems using groundwater sources to produce the crops in the region. Energy utilization pattern in sprinkler irrigation system is shows in Fig. 1. It depicts that in sprinkler irrigation system most 76.3% was required as electrical energy to run the system in farmer fields while PVC segment and GI material consumed 6.7 percent and 17 percent, respectively.

Input-Output Energy

The energy consumption for raising chick pea crop under sprinkler and flood irrigation is given in Table 2. The total input energy consumption was higher in sprinkler irrigation than flood irrigation. There were not many variations in total input energy consumption due to sprinkler irrigation at different farmer's field in the study area. The Total input energy consumed was highest for sprinkler irrigation because extra energy was required to operate and maintain the pressure and run the system. The flood irrigation consumed minimum energy due to there is no need of extra energy to run any system. Table 2 clearly indicates that minimum input energy of 12345 MJha^{-1} was observed in Chhatrakhar village of Mungeli block, Dani pendri of Pathariya and Barbaspu Mungeli of Lormi. Average input energy required for sprinkler irrigation system, of 12538.3, 12971.3 and 12971.3 MJha^{-1} was recorded in Mungeli, Pathariya and Lormi block, respectively. Average energy of the Mungeli district was 12826.92 MJha^{-1}.

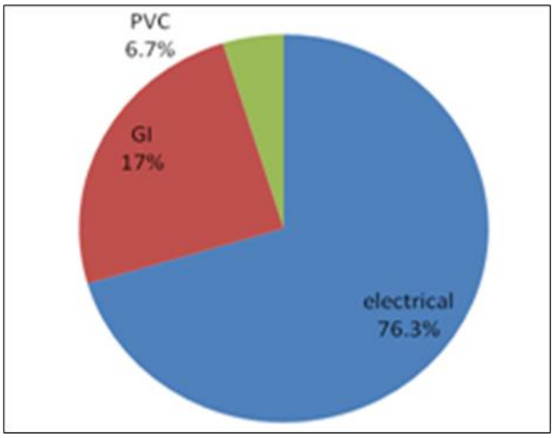

Fig 1: Energy utilization pattern of portable sprinkler irrigation system

Table 2: Input and output energy at different farmer's field of Mungeli region

Block	Villages	Input energy		Output energy	
		Flood	Sprinkler	Flood	Sprinkler
Mungeli	Chhatrakhar	15780	12345	15600	30640
	Dhanagon	15620	12450	15450	29980
	Fandwani	15378	13000	15259	30150
	khapri	15568	12358	15360	29800
	Average	15586.5	12538.3	15417.3	30142.5
Pathariya	Dani pendri	15750	12445	15650	30461
	Chandali	15520	13450	15750	29893
	Junwani	15500	13450	15259	30514
	Lamti	15560	12540	15340	29984
	Average	15582.5	12971.3	15499.8	30213
Lormi	Barbaspur	15850	12445	15350	30261
	Sukli	15520	13450	15342	29978
	Jotpur	15500	13450	15234	30435
	kanchanpur	15560	12540	15240	29948
	Average	15607.5	12971.3	15291.5	30155.5
Total average		15592.17	12826.92	15402.83	30170.33

Output Energy

It is clear from the Table 2 that irrigation markedly influenced output energy of grain, stover and total. Maximum average output energy of 30213 MJ ha^{-1} was recorded under sprinkler irrigation in Pathariya block, while the minimum was under flood irrigation. Maximum output energy for production of chick pea through sprinkler system in the region was 30170.33 MJha^{-1}. The higher output energy was found when chick pea grown under sprinkler irrigation compared to flood irrigation mainly due to higher grains and straw yields of chick pea. Similarly the average output energy of 30142.5 and 30155.5 MJ ha^{-1} under sprinkler irrigation were found at Mungeli and Lormi block, respectively given in Table 2.

Specific Energy

Specific energy is the input energy required for production of per kg of gain. Fig 2 shows the specific energy observed in flood and sprinkler irrigation at different farmer's field of four different villages of Mungeli block. Maximum specific energy value was recorded under low under flood irrgation. This was due to lower grain and stover yield of chick pea under flood irrgation. The minimum specific energy was recorded under sprinkler irrigation.

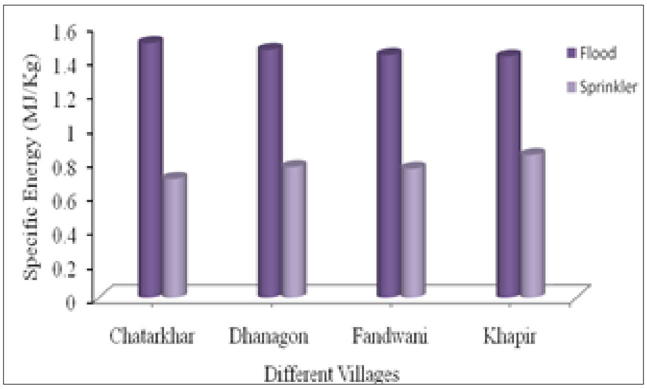

Fig 2: Specific Energy in Mungeli Block

The average value of specific energy for flood and sprinkler irrigation was 1.54 and 0.77. Similarly the value of specific energy obtained for production of chick pea at different farmer's field of Pathariya and Lormi blocks under flood and sprinkler irrgation can be seen in Fig. 3 and Fig. 4, respectively.

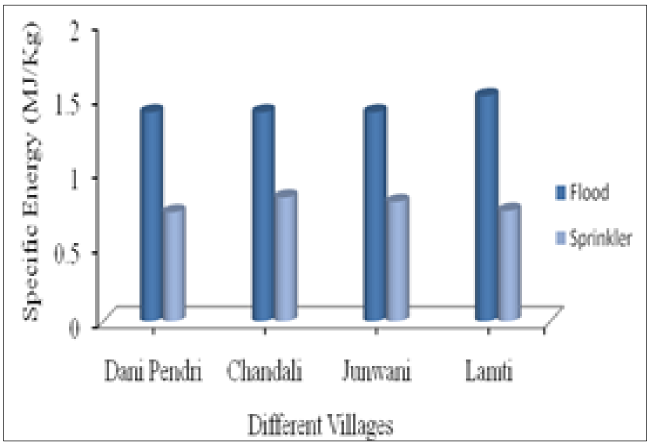

Fig 3: Specific Energy in Pathariya Block

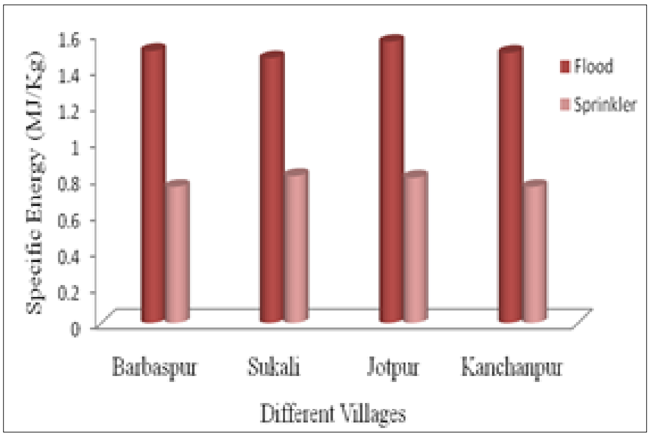

Fig 4: Specific Energy in Lormi Block

Energy Ratio or Energy Use Efficiency

It is the ratio output energy to input energy. It is obvious from the Fig. 5 under reference that sprinkler irrigation system recorded better out-input energy ratio of than flood irrigation for cultivation of chickpea crop in one ha land at different farmer's field in Mungeli block.

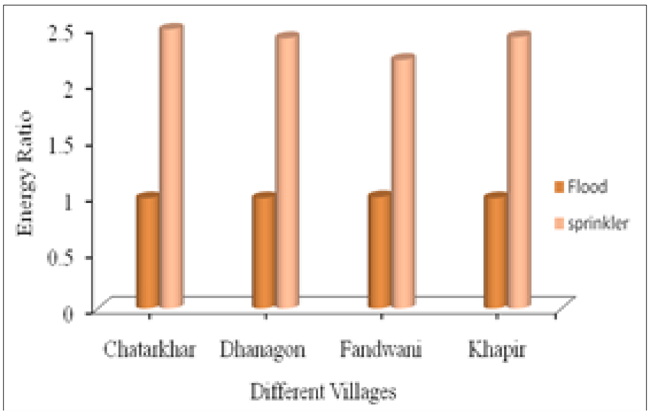

Fig 5: Energy Ratio in Mungeli Block

This is due to higher grains yields of chick pea with efficient utilization of applied water under sprinkler irrigation than flood irrigation. The mean of the out-input energy ratio were 2.4 and 0.98 under sprinkler irrigation and flood irrigation, respectively in Mungeli block. Similarly the value of energy efficiency obtained for production of chick pea at different farmer's field of Pathariya and Lormi blocks under flood and sprinkler irrgation can be seen in Fig. 6 and Fig. 7, respectively.

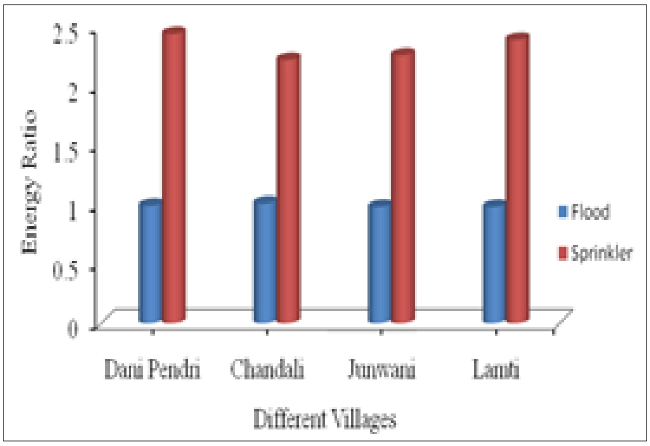

Fig 6: Energy Ratio in Pathariya Block

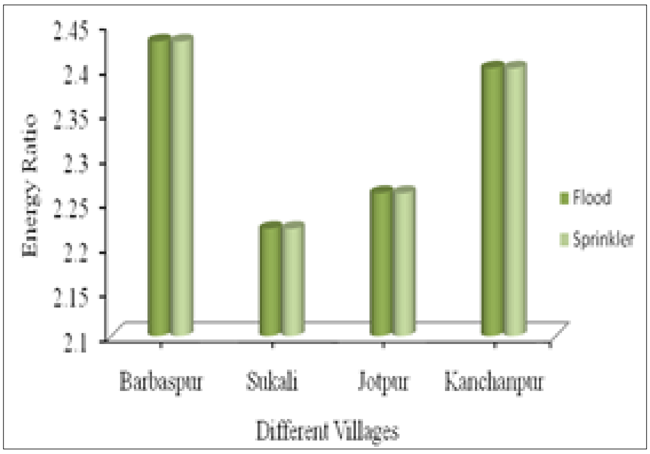

Fig 7: Energy Ratio in Lormi Block

The energy consumption for raising chick pea crop under sprinkler and flood irrigation is given in Table 2. The total input energy consumption was higher in sprinkler irrigation than flood irrigation. There were not many variations in total input energy consumption due to low sprinkler irrigation at different farmer's field in the study area. The Total input energy consumed was highest for sprinkler irrigation because extra energy was required to operate and maintain the pressure and run the system. The flood irrigation consumed minimum energy because there is no need of extra energy to run any system.

Conclusion

It may be concluded that the energy utilization under sprinkler irrigation systems can be quantified and stratified for sound planning of sustainable systems. It is depicted from results that in sprinkler irrigation system 76.3 percent energy consumed as electrical energy to run the system in farmer fields while PVC segment and GI material consumed 6.7 percent and 17 percent, respectively. The input energy, output energy, specific energy and output- input energy ratio under sprinkler irrigation for production of chickpea in Mungeli district were found to be 12538.25 (MJ ha^{-1}), 30142.5(MJ ha-

[1]), 0.77 (MJ kg^{-1}), 2.4, respectively. This result into savings of water and pumping time thus reducing energy costs. The energy-water productivity is an integrated indicator of water and energy use in agricultural production systems. It captures the efficiency of systems which are energy intensive as well as water scarce. The data gathered from the study will help the farmers of the region to calculate irrigation inputs as diesel or electrical energy and guide them for operating the system efficiently.

Response of Yield

The yield response of chick pea at different farmer's field in Mungeli region is shown in Fig. 8 which depicts that the grain yield of chick pea was influenced by method of irrigation. The maximum grain yield was obtained under sprinkler irrigation whereas the minimum was under flood irrigation. The sprinkler irrigation gave average 50 percent higher yield over the flood irrigation. The higher yield obtained sprinkler irrigation may be ascribed due to. Comparable yields under sprinkler irrigation were achieved due to favorable influence of plant growth and yield attributes of chick pea and avoidance of moisture-stress conditions by frequent irrigation under sprinkler system. Yield was reduced when irrigation was applied to the crop at different field in the study area by flood. This may be due to poor water-use efficiency which affect yield attributes of crop. The average yield of chick pea in the Mungeli region were 1200 and 800 kg ha^{-1} under sprinkles and flood irrigation.

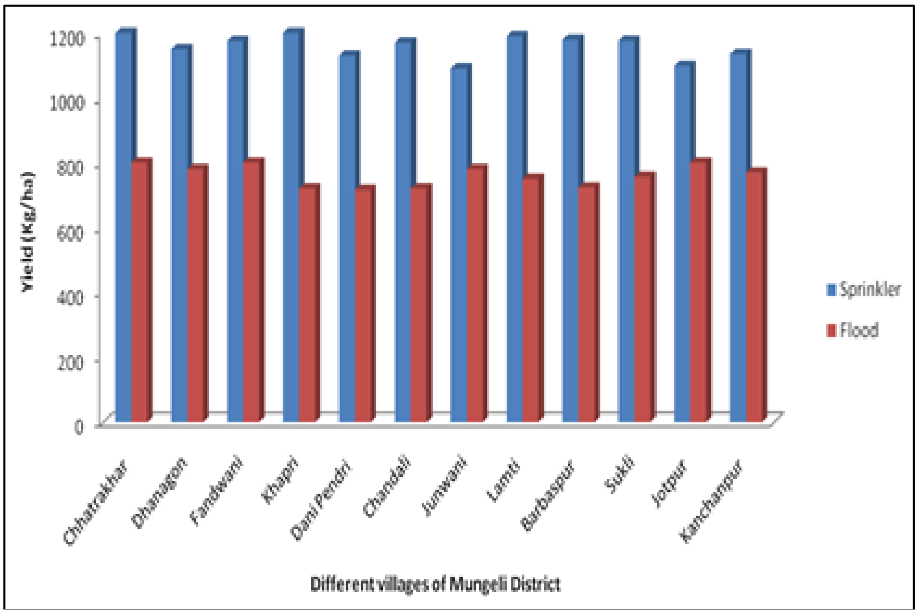

Fig 8: Response of yield of chick pea in Mungeli region

References

1. Alipour A, Veisi H, Darijani F, Mirbagheri B, Behbahani AG. Study and Determination of Energy Consumption to Produce Conventional Rice of the Guilan Province. Journal of Agricultural Engineering. 2012; 58(3):99-106.
2. Duran Yavuz, Aramazan Topak, Anurcan Yavuz. Determining Energconsumption of Sprinkler Irrigation for Different Crops in Konya Plain. Turkish Journal of Agricultural and Natural Sciences. 2014; 1(3):312-321.
3. Michael AM. Irrigation - Theory and Practices. Vikas Publishing House Pvt Ltd. New Delhi, India. 1996; 549-570.
4. Mittal VK, Dhawan KC. Energy parameters for raising crops under various irrigation treatment in Indian agriculture. Agriculture, Ecosystems and Environment. 1989; 25(1):11-25.
5. Mittal VK, Mittal JP, Dhawan KC. Research digest on energy requirements in agriculture sector (1971, 1982). Coordinating Cell, All India Coordinated Research Project on Energy Requirements in Agricultural Sector, Punjab Agricultural University. Ludhiana, 1985.
6. Mrini M, Senhaji F, Pimentel D. Energy analysis of sugarcane production in Morocco. Environment, Development and Sustainability. 2001; (3):109-126.
7. Ozkan B, Akcaoz H, Fert C. Energy input output analysis in Turkish agriculture. Renewable Energy. 2004; 29(1):39-51.
8. Rafiee S, Mousavi Avval SH, Mohammadi A. Modeling and sensitivity analysis of energy inputs for apple production in Iran. Energy. 2010; 35(8):3301-3306.
9. Schroll H. Energy flow and ecological sustainability in Danish agriculture. Agriculture, Ecosystems & Environment. 1994; 51(3):301-310.
10. Singh G, Singh S, Singh J. Optimization of energy inputs for wheat crop in Punjab. Energy Conversion and Management. 2004; 45(3):453-465.
11. Singh JM. On farm energy use pattern in different cropping systems in Haryana, India. International Institute of Management University of Flensburg, Sustain and Manage, Master of Science, Germany, 2002.
12. Smerdon ET, Hiler EA. Energy in irrigation in developing countries. In: Proceeding of the International Conference an Water and Water Policy in World Food Supplies. May 26-30, Texas A & M University, USA, 1985.
13. Khan S, Khan MA, Hanjra MA, Mu J. Pathways to reduce the environmental footprints of water and energy inputs in food production. Food Policy. 2009; 34(2):141-149.