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Techno-economic feasibility study of raingun for irrigating wheat and chickpea in vertisol

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Abstract
The techno- economic study of irrigation of wheat and chick pea using rainguns was carried out at ICAR-Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh during 2009-2010. Different rainguns with lower to higher discharge and radius of throw were used. Study indicated that raingun with lower discharge rate take more time to irrigate unit area. The cost of cultivation of wheat and chick pea was calculated and it was found that using raingun with lower discharge rate it was less as compared to rainguns with higher discharge rates and radius of throw. Raingun T3 having highest discharge rate could be used for irrigating 1.99 -2.98 ha of wheat and 3.11- 4.67 ha of chickpea with 8-14 hour daily operation of system. Raingun T1 with smallest discharge and radius of throw might be used for irrigation of 0.89-1.56 ha wheat and 1.40 -2.45 ha of chick pea in 8-14 hour duration of operation. The net benefit and benefit cost ratio using yield data and market price of wheat and chickpea was estimated. This raingun having maximum B:C of 2.69 and 1.92 for wheat and chickpea seems to be beneficial. Higher net benefit but least B:C could be fetched due to using raingun T3 with higher discharge rate for irrigating wheat and chickpea.

Keywords: raingun, wheat, chickpea, cost of cultivation, benefit cost ratio, techno-economic study

1. Introduction
Indian agriculture has to produce ever-increasing quantity of food, feed, fibre and fuel to meet the need of its growing population. Irrigation along with other technological interventions has played vital roles in increasing food production. Due to competing demand of water from non-agricultural sectors such as domestic and industries, the share of water for agriculture is reducing. Therefore, optimum and efficient utilization of water in agriculture for irrigation assumes great significance. In India, conventional surface irrigation methods to pressurized irrigation systems are in use. Conventional surface irrigation methods are utilized in about 90% irrigated area in India. These have low field level application efficiency upto 40% because of huge conveyance and distribution losses [1, 2]. The conventional irrigation has created many soil, water and environmental problems such as; soil salinity; seepage, conveyance and evaporative losses; higher energy cost; faster soil erosion; more wastage of fertilizer and other nutrients, pollution. It also results in higher weed population; increased operational difficulties and cost; uncontrolled, unmeasured and uneven water supply.
Pressurized irrigation includes micro irrigation, sprinkler irrigation system as well as raingun. Pressurized irrigation systems are among the efficient irrigation techniques which may achieve field level application efficiency in the range of 60-95%, due to minimized surface runoff and deep percolation losses [3, 4]. Thus pressurized irrigation may allow more crop per unit water, and allow crop cultivation in an area where available water is insufficient or land terrain is difficult to be irrigated through surface irrigation methods. The coverage area under theses methods is growing fast in India with a potential area of 27 million-hectare land [5, 6].
Sprinkler irrigation is suited for most row, field and tree. These are suitable for almost all field crops like wheat, gram, pulses, vegetables, cotton, soya bean, tea, coffee, and other fodder crops. Rainguns are similar to impact sprinkler, except that they generally operate at very high pressures. Conventional sprinklers need 2.5 to3.5 kg/cm^2 operating pressure which discharge 1500-3000 Lph with wetted diameter of 24-35 m. However, Gun sprinkler or raingun require 4.0-6.0 kg/cm^2 and discharge 5000-45000 Lph with wetted diameter of 60-80 m [7]. The trials conducted in different parts of the country revealed water saving due to sprinkler system from 16-70% over traditional method with yield increase from 3-57 % in different crops and agro climatic conditions [8].
Rain guns are most suitable for a variety of climates like tropical, temperate and humid climates in India. These have long wear life and low maintenance. They provide uniform distribution profile with adjustable jet breaker arrangement. Rain guns have reduced risk of

structural damage of soil and delicate plants due to evenness and lightness of watering. They can be easily used with portable irrigation system. These are available in full circle and part circle models. These can be recommended for field crops like sugarcane, pulses, oil seeds, cereals, tea, coffee, and vegetables. The rain gun irrigation system was found effective in sugarcane crop to increase in cane yield by 15%, save the irrigation water by 32% and increase the water-use-efficiency by 1.7 times more compared to furrow irrigation. It has shown equally good results to drip irrigation as regards cane yield [9]. Raingun irrigation during early crop season of sunflower helped in saving water when the soil infiltration rate was very high and need of water in the rootzone was less. Using raingun irrigation system, 30.8% and 28.3% higher water use efficiency and 21.1% and 9.0% more water application efficiency was achieved as compared to basin and furrow irrigation system, respectively [10]. Rainguns of various discharge rate and radius of throw are available. Economics benefits of irrigation systems are important aspect for wider applicability in many crops. Therefore, a study was carried out to understand about area coverage, cost of cultivation and benefits of different rainguns for irrigation of wheat and chickpea, important crops grown in vertisol.

2. Methodology

The study was carried out for irrigation of wheat and chickpea at ICAR- Central Institute of Agricultural Engineering, Bhopal, Madhya Pradesh during 2009-2010. The soil of experimental area is black vertisol (Table 1). Wheat and chickpea are among important crops grown in the area.

2.1 Crop water requirement

The water requirement of crops was estimated based on crop duration, crop coefficient based on crop growth stages and evapotranspiration (Table 2 and 3) [11].

2.2 Techno-economic analysis

Area covered under different rainguns was calculated based discharge rates, radius of throw and duration of operation which was taken as 8, 10, 12 and 14 hours for wider applicability. The cost of cultivation of wheat and chickpea was evaluated based on price of different rainguns, system life15 years, rate of interest and depreciation both 10% and repair and maintenance cost at rate of 2% of cost of raingun system. The salvage value assumed was 10% of system cost. The gross benefit was based on the crop yield and price of wheat and chickpea. The net benefit from wheat and chickpea was calculated by deducting cost of crop cultivation from gross benefit [12].

Table 1: Physical properties of soil at experiment site

Sl. No.	Properties	
1.	Soil texture:	
	Clay	49.7 - 53.7 %
	Silt	27.9 - 29.6 %
	Sand	8.2 - 20.8 %
	Gravel	2.9 - 3.8 %
2.	Soil structure	Sub angular blocky
3.	Bulk density	1.39 -1.75 g/cc
4.	Porosity	38.0 – 40.0 %
5.	Water holding capacity	33.0 – 36.0 %
6.	Field capacity	28.5 – 31.0 %
7.	Permanent wilting point	19.0 - 19.5 %
8.	Infiltration rate	1.1 cm/h

Table 2: Crop coefficient of wheat and chick pea

Crops	Crop coefficient			
	$K_{c\ init}$	$K_{c\ dev}$	$K_{c\ mid}$	$K_{c\ end}$
Wheat	0.7	0.94	1.15	0.32
Chick pea	0.4	0.7	1.00	0.35

Table 3: Crop growth stages of wheat and chick pea

Crop	Crop growth stages, days				
	Initial	Development	Mid season	Late season	Total
Wheat	17	50	58	25	150
Chick pea	27	41	41	26	135

3. Results and discussion

3.1 Area coverage and duration of irrigation

Considering the system efficiency of raingun irrigation as 80%, the maximum daily water requirement of chickpea and wheat were worked out to be 4.63 mm/d and 7.25 mm/d, respectively (Table 4). Rainguns T1 might have taken 5.72 and 8.95 hours to irrigate one hectare of chickpea and wheat, respectively. While, raingun T3 could have taken 2.57 and 4.03 hours respectively. Less duration with raingun T3 may be attributed to higher discharge rate and radius of throw.

Table 4: Area coverage and duration of irrigation with various type of rainguns

Raingun type	Radius of throw, m	Discharge, lps	Area covered per unit operation of single unit, m^2	Duration to irrigate one ha of crop during peak water requirement, h	
				Chickpea (4.63 mm/d water)	Wheat (7.25 mm/d water)
T1	23	2.25	1662.57	5.72	8.95
T2	29	3.5	2643.14	3.67	5.75
T3	33	5.0	3422.57	2.57	4.03

The area of wheat and chick pea that could be irrigated using raingun with daily duration of irrigation as 8 - 14 hours has been presented in Table 5. It may be observed that raingun T3 which has highest discharge and radius of throw among them covered higher area as compared to other two rainguns. Raingun T3 might be used for irrigating 1.99 -2.98 ha of wheat and 3.11- 4.67 ha of chickpea with 8-14 hour daily operation of system. While, raingun T1 with smallest discharge and radius of throw might be used for irrigation of 0.89- 1.56 ha wheat and 1.40 -2.45 ha of chick pea in same duration of operation. With same duration of operation of system area irrigated under chickpea was higher as compared to that of wheat. It is due to obvious reason that water requirement of chick pea was lower than wheat.

Table 5: Area under wheat and chickpea to be irrigated with various raingun

Duration of irrigation, h	Wheat area, ha			Chickpea area, ha		
	T1	T2	T3	T1	T2	T3
8	0.89	1.39	1.99	1.40	2.18	3.11
10	1.12	1.74	2.48	1.75	2.72	3.89
12	1.34	2.09	2.98	2.10	3.27	4.67
14	1.56	2.43	3.47	2.45	3.81	5.45

3.2 The cost of cultivation of crop under raingun

The cost of cultivation of wheat and chickpea at CIAE Farm had been Rs, 23,915 and 18,145/- per hectare respectively. The cost of cultivation including three types of raingun irrigation system has been depicted in Table 6. The assumptions made for the calculations were the system life15 years, rate of interest and depreciation both 10% and repair and maintenance cost at rate of 2% of the cost of raingun system. The salvage value assumed to be 10% of system cost.

Table 6: Per hectare cost of cultivation of crop under raingun

Crop	Raingun Type	Cost of raingun system, Rs	Annual interest, Rs	Annual depreciation, Rs	Repair and maintenance, Rs	Cost of raising crops, Rs	Cost of crop cultivation, Rs
Wheat	T1	35000	1575	2100	700	23915	28290
	T2	40000	1800	2400	800	23915	28915
	T3	60000	2700	3600	1200	23915	31415
Chick pea	T1	35000	1575	2100	700	18145	22520
	T2	40000	1800	2400	800	18145	23145
	T3	60000	2700	3600	1200	18145	25645

3.3 Techno-economic feasibility of raingun

3.3.1 Net Benefit

The mean weighted yield of wheat was 4.735 t/ha and that of chickpea 2.345 t/ha. The cost of cultivating wheat and chickpea at ICAR- Central Institute of Agricultural Engineering, Research Farm during study period was Rs. 23,915 and that of chickpea, Rs. 18,145 per hectare. Total income fetched through the production of above crops was Rs. 1, 04,416 and Rs. 65,649 per hectare, respectively. The net income fetched by theses crops were Rs. 80,501 and Rs. 47,502 per hectare, respectively with unit price of Rs. 22,050 and Rs. 28,000 per ton.

With varying duration of operation of raingun varying area of wheat and chick pea could be irrigated. Accordingly, the cost of cultivation, and net benefit changed. The estimated values for above under wheat and chick pea have been presented in Table 7 and 8. With increasing discharge rate net benefit increased but B:C ratio decreased. Higher net benefit but least B:C could be fetched due to using raingun T3 with higher discharge rate.

Table 7: Net benefit of irrigation with raingun in wheat

Parameters for raingun irrigation	Parameter values			
Duration of irrigation, h	8	10	12	14
Raingun,T1				
Area irrigated, ha	0.89	1.12	1.34	1.56
Cost of cultivation, Rs	25178	31685	37909	44132
Net Benefit, Rs	67744	85251	101996	118742
Raingun,T2				
Area irrigated, ha	1.39	1.74	2.09	2.43
Cost of cultivation, Rs	40192	50312	60432	70263
Net Benefit, Rs	104934	131356	157778	183445
Raingun,T3				
Area irrigated, ha	1.99	2.48	2.98	3.47
Cost of cultivation, Rs	62516	77909	93617	109010
Net Benefit, Rs	145254	181020	217515	253281

Table 8: Net benefit of irrigation with raingun in chickpea

Parameters for raingun irrigation	Parameter values			
Duration of irrigation, h	8	10	12	14
Raingun,T1				
Area irrigated, ha	1.4	1.75	2.1	2.45
Cost of cultivation, Rs	31528	39410	47292	55174
Net Benefit, Rs	60396	75495	90594	105693
Raingun,T2				
Area irrigated, ha	2.18	2.72	3.27	3.81
Cost of cultivation, Rs	50456	62954	75684	88182
Net Benefit, Rs	92683	115641	139024	161982
Raingun,T3				
Area irrigated, ha	3.11	3.89	4.67	5.45
Cost of cultivation, Rs	79756	99759.1	119762	139765
Net Benefit, Rs	124447	155658	186870	218082

3.3.2 Net benefit cost ratio

Net benefit and cost ratio due to irrigation of wheat and chick pea with various rain guns has been presented in Figure 1. The B:C values for chickpea was found less than that of wheat due to less net benefit from chickpea as compared to wheat. It could be inferred that irrigation of wheat and chick pea using raingun T1 has maximum B:C of 2.69 and 1.92, respectively over others. However, raingun T3 having higher coverage area have B:C of 2.32 and 1.56, respectively for wheat and chickpea seems to be least beneficial due to its higher cost as compared to raingun T1 and T2 with lesser coverage area. Raingun T1 and T2 have 16% and 13% higher B:C, respectively for wheat and 23% to 18% higher for chickpea.

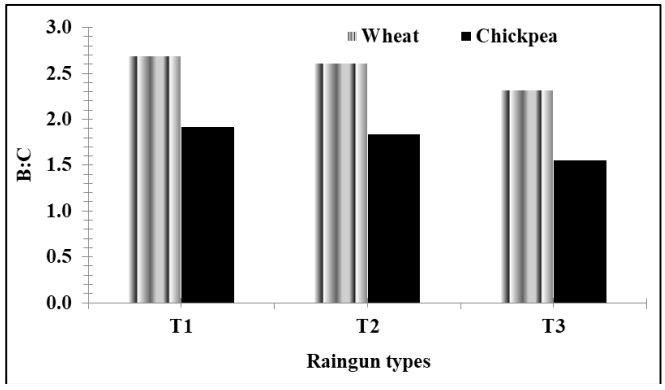

Fig 1: B:C of wheat and chickpea irrigated with different rainguns

4. Conclusions

The techno- economic study of irrigation of wheat and chick pea using different type of rainguns with lower to higher discharge and radius of throw indicates that raingun with lower discharge rate take more time to irrigate unit area. The cost of cultivation using raingun with lower discharge rate was less due to its less price as compared to rainguns with higher discharge rates and radius of throw. It is projected that raingun T3 could be used for irrigating 1.99 -2.98 ha of wheat and 3.11- 4.67 ha of chickpea with 8-14 hour daily operation of system. Raingun T1 with smallest discharge and radius of throw might be used for irrigation of 0.89- 1.56 ha wheat and 1.40 -2.45 ha of chick pea in 8-14 hour duration of operation. This raingun having maximum B:C of 2.69 and 1.92 for wheat and chickpea seems to be beneficial. Higher net benefit but least B:C could be fetched due to using raingun T3 with higher discharge rate.

5. References

1. INCID. Drip irrigation in India. Indian national committee on irrigation and drainage. New Delhi, 1994.
2. Rosegrant Mark W. Water resources in the twenty-first century: challenges and implications for action, food and agriculture, and the environment discussion paper 20, international food policy research institute, Washington DC, USA, March, 1997.
3. Heermann DF, Wallender WW, Bos MG. Irrigation efficiency and uniformity. In: Hoffman GS, Howell TA, Soloman KH. (Eds), Management of farm irrigation system. ASAE, St. Joseph MI, 1990, 125-149.
4. Postel S. Redesigning irrigated agriculture. In: Stark, L. (Eds). State of the world 2000. W. W. Norton and Co., New York, 2000, 39-58.
5. Narayanamoorthy A. Drip irrigation in India: can it solve water scarcity. Water policy. 2004; 6(2):117-130.
6. RTFM. Report of task force on microirrigation, (Chairman: N. Chandrababu Naidu), Ministry of Agriculture, Government of India, 2004.
7. Phocides A. Handbook on pressurized irrigation techniques, FAO. Rome, 2001.
8. INCID. Sprinkler Irrigation in India. Indian national committee on irrigation and drainage, New Delhi, 1998.
9. Shinde PP, Deshmukh AS, Katake SS. Water management with rain gun sprinkler irrigation for sugarcane. Agriculture section 1. Laboratory and field studies on Beauveria Brongniartii (SACC.) petch against holotrichia serrata f. (Coleoptera: scarabaeidae) in sugarcane abstracts of papers presented at the 66th annual convention Chandigarh, 2004.
10. Rana M, Arshad AM, Masud J. Effect of Basin, Furrow and raingun sprinkler irrigation systems on irrigation efficiencies, nitrate-nitrogen leaching and yield of sunflower. Pakistan journal of water resources. 2006; 10(2):http://www.pcrwr.gov.pk/Journals/Vol.no.%2010 (2)/1-Effect%20of%20Basin%20-%20Rana, Arshad&Masud%20-10_1_.pdf.
11. Allen Richard G, Pereira Luis S, Raes Dirk. Crop Evapotranspiration, guidelines for computing crop water requirements, Irrigation and Drainage Paper 56, Food and Agriculture Organization of the United Nations, Rome, 1998, 300.
12. Singh RM, Bhandarkar DM, Singh DK, Reddy KS, Rao KVR, Mathankar SK *et al*. Techno-Economic Feasibility of Drip Fertigation in Guava (*Psidium guajava* L.). Environment & Ecology. 2012; 30(2):271-274.