Energy Inputs and Wheat Production

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Abstract

The effects of energy inputs from various sources on wheat production per hectare and energy utilization pattern of selected treatments were studied at the Water Resources Institute, National Agricultural Research Centre, Islamabad, Pakistan. Treatments were grouped according to available irrigation sources and represented four levels ranging from fields with permanent sources of irrigation to the fields without irrigation. Three mechanized irrigation treatments were compared with ‘Barani’ (rainfed) farming system. The seed rates, green manuring, soil type, method of cultivation and harvesting were almost constant for all treatments. Crop production per hectare exhibited a good response to increase in energy consumption for irrigation per hectare. The research findings revealed that with the increased and efficient level of irrigation system, there is an increase in total energy requirements. However, increased inputs of energy also resulted in an increased crop production with reduction in the cost of production on irrigated fields from ‘Barani’ fields on the basis of per unit of marketable product. The water use efficiency remained the lowest under Basin Complete Irrigation System. Whereas it was the highest in the fields of supplemented irrigation with Raingun sprinklers.

Key World: Sprinkler, Basin, Irrigation, Rainfed.

Introduction

Rather than having to pay huge food import bills, it is more logical to invest adequately in the agriculture sector of the nation’s economy to become more self-reliant in the food production and at the same time generating much needed employment for the large rural labor force, thereby reducing undesirable mass urban migration (Lewie, 1984). Energy, in many ways, the key to increasing agriculture productivity, but energy supplies are not assessable to the Pakistani farmers in sufficient quantities to allow yield potential to be attained. This is particularly serious as population growth rate begins to outpace food production rate in the country. Without a radical change of policy both by individual and the government as a whole in favor of more investment both financial and energy, in Pakistan agriculture than the present unhealthy situation will only deteriorate. Wheat is an important crop in Pakistan and throughout the world. After an impressive growth of 6.1% in 1999 – 2000, the growth in agriculture sector turn almost negative in 2001. The main reason ascertains was the acute shortage of water in cropped area (Government of Pakistan, Planning Commission 2001). To cope with the ever-
growing demand for wheat in Pakistan for its rapidly increasing population under the scarcity of irrigation (the main cause of negative growth), it becomes essential that the water is used more efficiently.

Pakistan comprises fertile soils having varieties of climates suitable for growing various crops. It has a well-developed irrigation system. However, out of the total irrigated area of 18.06 million hectares, 3.07 million hectares is irrigated through tubewells. Whereas, 6.99 million hectares are irrigated through canal + tubewells in 1999-2000 (Pakistan Statistical Year Book 2001). Pakistan is not rich in non-renewable energy sources that run the prime movers of water pumps. Therefore, even in irrigated areas a lot of culturable areas could not be cultivated. Pattern of irrigation application can play a major role in this respect. Keeping in view the energy crises and drought conditions in the country it is imperative to select an energy efficient irrigation system. As it is necessary not only to procure sufficient energy to improve agricultural output, but to use that energy in most effective way technically and economically. This study was therefore, undertaken with the objectives to determining the relationship between crop productivity and commercial energy input in irrigation application and to compare cost of performance of the two levels of sprinkler irrigation system and complete basin irrigation system with Barani (rainfed).

Methodology

A study was conducted at the research farm of 7 ha at the Water Resources Institute (WRI), National Agricultural Research Centre (NARC), Islamabad. NARC (33° 12’ N Lat and 73° 08’ E Long) lies in the Islamabad district and is about 15 km from the district head quarter. The soil of the area is from piedmont plain and its texture is silty clay loam. Climatically, the area falls under subhumid continental climate. Most of the area in dry-farmed and only a small part is under cultivation with tubewell irrigation (Khanzada, S.K. 1976). The rainfall were above 1000 mm before 1999, however, during present drought conditions the total rainfall reduced to less than 1000 (Agricultural Meteorology Project, 2001). One of the major crops of the region is wheat. The farm was divided into four blocks (according to methods of irrigation).

In Block I, plots were irrigated with near by tubewell. The pumping motor of the tubewell was 7.5 kW (10hp). One irrigation before sowing and 5 after sowing of the crop were given at an interval of almost one month or so according to crop water requirement. In Block II, the plots were irrigated with sprinkler gun (Py1 – 50) with 16 mm nozzle. The power of motor used was 11.19 kW (15 hp). The depth of irrigation water varied from 2.85 mm to 8.17 mm. One irrigation before and five after sowing the crops were given at an interval of one month.

The plots in Block III got three time small showers with sprinkler gun of (Py1 – 50) with 16 mm nozzle after sowing the crop. Maximum depth of water on these plots remained 11.4 mm.

The plots in Block IV were rainfed (without permanent source of irrigation).
As a whole, the farming was mechanized. The crop of ‘Dhaincha’ \textit{(susbania sp)}, as a green manure, was grown before sowing of wheat. At its maturity, ‘Dhaincha’ was buried with disk plowing. Non of the chemical fertilizer was applied. In general four harrowing were done for the seed bed preparation. A seed drill was used for sowing of wheat. The average seed rate was 100 kg/ha. The crop was harvested with combine harvester.

For each plot, information was collected on all kinds of energy inputs. Sources of physical energy used on these farms were human labour, electric motor, tractor and combine harvester. To compute the energy inputs from different power sources, the following procedure was adopted.

For the calculation of energy input from human labor, the product of man hours and its estimated power was used. It was set equal to 0.075 kW (0.1 hp) \textit{(Khan and Singh, 1997)}. To calculate the energy inputs from electric motors, the product of number of motor hours, power rating of motor and load factor was used. Load factor = Ratio of actual electricity consumed as measured on the energy meter to the energy that would be at the rated power of the motor (average load factor = 1). To calculate the energy consumption by tractor and combine harvester, the following formula was used. Energy consumption by tractor or combine (kWh/ha) = Fuel consumption of tractor or combine harvester per hour (/h) X caloric value of diesel (kW/l) X Number of hours the tractor or combine harvester worked per hectare (/ha) \textit{(Khan, 1994)}. The caloric value of diesel in Pakistan is 10.46 \textit{(ENERCON, 1989)}.

The energy efficiency ratio is the ratio of dietary energy value of agricultural output to the fossil energy expended to obtain it \textit{(Output : Input Ratio expressed in energy)} \textit{(Bonny, 1993)}.

The yield of the crop was recorded. Computation of energy input for all operations were made on per hectare basis. Plots understudies were economically analyzed to examine gross margin and benefit cost ratio. The cost of labour was assumed to be equal to the cost of labour hours available in the market. The prevailing price of seed at the time of sowing was used for estimating the cost of home produced seed. The cost of production included the cost of all operations performed with various power sources, i.e., human labour, electrical energy, tractor and combine harvester and cost of seed of wheat and ‘Dhaincha’ needed to grow one hectare of the crop. The gross value of the output includes the value of crop (wheat) and byproduct (wheat straw). Gross margin was defined as the gross value of product minus the cost of production \textit{(Abbott and Makeham, 1979)}.

The water utilization by the crop is generally described in term of water use efficiency (kg/ha – cm or kg/m$^3$). It can be defined as the ratio of crop yield (Y) to the total amount of water used in the field (WR). Whereas, \textit{WR} = \textit{IR} + \textit{ER} + \textit{S}. Here ‘IR’ is irrigation water applied to the crop; ‘ER’ is effective rainfall; and ‘S’ is soil profile contribution. In this study water use efficiency was also calculated.
Result and Discussion

The average energy inputs per hectare covering labor, electricity use in pumping system, tractor and combine harvester for all the four treatments are given in Table I. The labour use during the crop production period was the lowest under ‘Barani’ farming system. Irrigation increased the total energy consumption, that remained the lowest under ‘Barani’ farming, whereas it was the highest under basin irrigation system. Although the motor used for pumping of water under basin irrigated condition was of lower power i.e 7.46 kW (10 hp) than the sprinkler irrigation system that was 11.19 kW (15 hp), yet the consumption of energy remained higher under basin irrigation due to longer hours of operation.

Tractor was used not only for land preparation but also for transportation of harvested and threshed material from field to store. During land preparation operation tractor took the longest time on the plots of sprinkler irrigation (Table II). The plots under this category were small in size. These were also unleveled compared to the plots of other categories. Moreover, because of higher yield in irrigated plots, tractor used for transportation was also higher than the ‘Barani’ plots. Energy consumption due to combine harvester remained almost the same for all categories of plots.

In general, total energy used per hectare increased as the mechanization level of irrigation increased (Fig. 1). In return, the yield also remained higher on irrigated plots. Water (irrigation) played the vital role in this connection. Even the minor irrigation at critical stages of the crop boosted the yield. The 50% increase in yield with minor irrigation with Raingun sprinkler from ‘Barani’ farming clearly indicates the importance of timeliness of agriculture operations. This importance of timeliness operation in crop production is very recognized as reported by Singh (1968). Irrigation, along with all other production practices have timeliness aspects. Penalties of not meeting timeliness requirement force the farmers in deciding about what power sources and equipment combination they should have within their economic reach to minimize timeliness penalties.

Energy efficiency ratio i.e. output - input ratios on all categories of plots were calculated. In all cases, the total energy output was greater than the total energy inputs. A significant difference was observed between Basin complete irrigation system, supplemented irrigation with Raingun sprinkler and ‘Barani’ farming (Fig 2). Water use efficiency indicated the benefits of irrigation water that has been utilized under different irrigation systems. Maximum efficiency occurred in the fields under the supplemented irrigation with Raingun Sprinkler (Fig. 2). The results indicated that this system was 160 % more efficient than basin complete irrigation system. The system was also 49% more efficient compared to ‘Barani’ farming system, where rains were the only source to fulfill the deficiency of water.

The value of output per hectare, cost of production, gross margin, and benefit cost ratio for the wheat crop are given in Table III and IV. Cost of production remained higher
on irrigated plots than ‘Barani’ farming. However, the value of output and consequently
gross margin also remained high in irrigated fields (Fig. 3). The cost of irrigation was the
major factor for this higher production cost. Although cost of the irrigation in Basin
complete irrigation system was 100% higher than supplemented irrigation with Raingun
sprinkler, yet the value of output was just 15% higher in farmer case. Higher
transportation charges on irrigation fields were due to higher yield compared to ‘Barani’
farming. Expenditure on seed and green manuring remained almost the same in all cases.
The cost of land leveling operation was not included in the category of complete basin
irrigation system as the plots were already in level condition before the start of study.
Land leveling is very important operation in complete basin irrigation system, but it is
also heavy energy consuming and cost substantial amount in total cost of production.
Were this cost included in the cost of production, the gross margin and benefit cost ratio,
which were already low (Fig. 4), would have further reduced in the fields of this
category.

Conclusion

A study was conducted on production of the wheat crop under different irrigation
systems. Comparison was between basin complete irrigation system, supplemented
irrigation using Raingun sprinkler and ‘Barani’ farming.

Barani farm used less energy and obtained lower yield compared to irrigated
farms. Increase in total energy consumption on per hectare basis from ‘Barani’ farming’
to irrigated fields was 25% on basin complete irrigation system, 14% on farms under
supplemented irrigation with Raingun sprinkler, 5% on farms under minor irrigation with
Raingun sprinkler. The yields on irrigated farms were higher than ‘Barani’ farming. The
increase in yield was 146% on basin complete irrigation system, 114% on supplemented
irrigated with Raingun sprinkler and 51% on minor irrigation with Raingun sprinkler.
Irrigation farms produced higher yields because in arid and semi-arid areas the crops do
need supplemental irrigation at proper time for better return. Value of output and
consequently the gross margin remained the lowest on ‘Barani farming system. The
increase in gross margin from ‘Barani’ farming was 200% on basin complete irrigation
system, 166% on the fields of supplemented irrigated with Raingun sprinkler, and 79%
on the fields of minor irrigation with Raingun sprinkler on per hectare basis.

The study observed the need to adopt efficient methods of irrigation in the
country, because the surface irrigation with low efficiency can not sustain the
requirement under present draught conditions. Supplemented irrigation with Raingun
sprinkler will not only reduce the energy cost on per unit of the produced product but also
achieve high irrigation efficiency.

References

Physical Energy Inputs in percent for four selected treatments for the production of wheat