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Energy Consumption and Production Pattern in Direct Drilling Wheat in Punjab

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Abstract

The study was conducted on input energy consumption for wheat production in irrigated condition at Punjab Agricultural University, Ludhiana. The results revealed that the highest input energy requirement of 15682.9 $MJha^{-1}$was recorded for conventional tillage (CT) compared 13189.4, 12467.6 and 12467.6 $MJha^{-1}$ for rotavator (RT), happy seeder (HS) and zero tillage (ZT), respectively. Nitrogen (N) application showed a positive relationship with input energy consumption and highest of 18297.0 $MJha^{-1}$ was recorded with 150 kg Nha^{-1} compared 15164.5, 13651.3, 6694.7 $MJha^{-1}$ for 0, 100 and 125 kg Nha^{-1}, respectively. The main source of input energy use was fertilizer and irrigation. The higher share of direct and non-renewable input energy consumption was recorded in CT and indirect and renewable input energy consumption was higher in HS, ZT and RT. Direct & renewable and indirect & non-renewable input energy showed a negative and positive relationship with N rates. CT wheat with 150 kg Nha^{-1} produced the highest total output energy. The results showed that the highest 10.48, 0.38 $kgMJ^{-1}$ and 3.96 $MJkg^{-1}$ of output: input ratio, energy productivity and energy specific under ZT, ZT and CT, respectively. However, the maximum NPK energy equivalent in biomass was recorded in CT. Input: output ratio, energy productivity and NPK energy equivalent showed negative relationship and energy specific showed a positive relation with N rates. CT showed the higher net gain of energy compared to direct drilling methods as ZT, HS and RT.

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Conventional tillage, Energy, Happy seeder, Nitrogen, Rotavator, Wheat, Zero tillage.

Introduction

From the era of Green Revolution, energy consumption has increased tremendously in agriculture and farming has become very energy intensive. Presently, farmers are using high energy to enhance production due to competition and some mismanagement on using inputs. However, energy consumption in agriculture is directly related to the development of technology in farming and the level of mechanization[3] Several studies have been

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conducted to know the energy consumption patterns in different crops and cropping systems at different situations all over the world[7,14,17] and all of them show the importance of how energy resources are used. It was evaluated the changes in wheat-maize energy consumption in India[7] and reported that the average values of energy consumption for wheat in low and high hills were 41.68 and 110.8 MJ/ha and for maize were 43.43 and 81.33 MJ/ha, respectively. Conducted the optimization of energy consumption for wheat production in Iran[1] and reported that average energy consumption for wheat production was 58367.69 MJ/ha and about 8755.1 MJ/ha of total energy could be saved while holding the constant level of wheat yield. The results of the other study showed that per hectare operational energy use and size of holdings were inversely related to each other. The average use of operational energy was 1028 MJ/ha for rain-fed wheat production. The highest operational energy was required for preparation of field for sowing. The source wise energy use was 3826 MJ/ha. The major source of input energy use was seed and fertilizer. The output-input energy ratio was 5.39. The energy was gap analysis showed that an additional investment of rupee one on energy use in the production of rain-fed wheat gave an additional income of Rs. 1.61[8]. In another study found that wheat crop utilized a total of 38356.39 MJ/ha of which utilization of fertilizer energy was 38.45% followed by diesel and machinery energy. Output-input energy ratio and energy productivity were recorded to be 3.13 and 0.16 kg of wheat/MJ, respectively[12]. Most of the studies were conducted on the pattern of energy consumption in irrigated and dry areas particularly the wheat grown with traditional methods but very little information available on the pattern of energy consumption of direct drilling wheat sown in Indo-Gangetic plains of India. However, the alternative techniques of the traditional methods of agriculture like zero tillage, happy seeder and rotavator technology for the planting of wheat and other crops were introduced recently. Several studies have been shown that these technologies have certain benefits like saving on fuel, water, time and labor over the conventional methods and proved to be efficient in energy conservation by saving fuel, irrigation water and labour. Efficient use of energies helps to achieve increased production, productivity and contributes to the economy, profitability and competitiveness of agriculture, sustainability in rural living[15]. Use of conservation techniques helps to improve and make to more efficient for the utilization of natural and energy resources[13]. It was reported that economic, efficient and sustainable use of energy based on the proper energy management[12]. It is seen that the importance has been given in many countries including Iran for the efficiently, sustainability and economical use of energy. The major objective of the present study was to study the energy input and output per hectare to produce of direct drilling wheat in irrigated areas of Punjab. It also identifies the method of planting wheat by which energy savings could be realized by the conventional method in order to reduce the energy consumption for wheat production. The input and output data were converted into energy using the standard conversion coefficients (Table 1). The irrigation data was converted into energy using the standard conversion coefficient (Table 1).

Table 1:Energy coefficient of input and output used in wheat production

Energy inputs /output	Unit	Energy equivalent (MJ/kg or MJ/l)
Seed	Kg	14.7[9,10]
Human power	Hour	1.96[7,15,9,20]
Machinery	Hour	62.7[19,15,14,4]
Irrigation	750 cubic meter	1.02[12]
Chemical	Kg	120[6,14,2]
Diesel	Liter	56.31[19,15,14,4]
Nitrogen	Kg	60.6[16]
Phosphorus (P_2O_5)	Kg	11.1[16]
Potassium (K_2O)	Kg	06.7[16]
Grain	Kg	14.7[9,10]
Straw	Kg	12.5[9,10]

Material and Methods
Study Area
Ludhiana representing the Indo-Gangetic alluvial plains is situated at the 30°56' N latitude and 75°52' E longitude at an altitude of 247m above mean sea level. It is characterized by the subtropical semi-arid type of climate with hot and dry summer (mid April to end of June), hot and humid summer monsoon

period (early July to the end of September), mild winter (October to November) and very cold winter (December to the end of February). The transitional seasons are post monsoon period (September to end of November) between the rainy and cold season and pre-hot season (March to mid April) between the cold and hot season. The mean minimum and maximum temperature, therefore, shows considerable fluctuation during summer and winter. Maximum air temperature above 47°C is received in summer monsoon months of July to September while recorded during the month of May and June and minimum temperature below 4°C is recorded during the month of December and January

Table 2:Amount of inputs and total energy equivalent of different inputs and machinery

Parameter	Unit	Quantity per hectare	Energy equ-ivalent (MJ)	Total energy equivalent (MJ)
Machinery	$Hrha^{-1}$		62.7	
Happy seeder		2.5		156.7
Zero tillage		2.5		156.7
Conventional tillage		8.05		504.7
Rotavator		5		313.5
Labour	$Hrha^{-1}$		1.96	
Happy seeder		13		25.5
Zero tillage		13		25.5
Conventional tillage		13		25.5
Rotavator		13		25.5
Irrigation	M^3		1.02	
Happy seeder		3750		3825
Zero tillage		3750		3825
Conventional tillage		3750		3825
Rotavator		3750		3825
Chemical	kg		120	
Happy seeder		0.625		75
Zero tillage		0.625		75
Conventional tillage		0.625		75
Rotavator		0.625		75
Diesel fuel	Lha^{-1}		56.31	
Happy seeder		10		563.1
Zero tillage		10		563.1
Conventional tillage		32.2		1812.8
Rotavator		20		1126.2
Nitrogen	$Kgha^{-1}$		60.6	
		0		0
		100		6060
		125		7575
		150		9090
Phosphorus	$Kgha^{-1}$	62.5	11.1	693.75
Potassium	$Kgha^{-1}$	30	6.7	201
Seed	$Kgha^{-1}$	100	14.7	1470

and frequent frosty spells are experienced. The average annual rainfall received is about 500-750 mm, most of which is received during the monsoon period from July to September. A few showers are, however, received during winter season also. The meteorological data recorded during the crop season (14 November 2009 to 13 April 2010). It revealed that a total rainfall of 44.4 mm was received during the crop season November 2009 to April 2010. Mean weekly maximum temperature of 24.8°C and mean a minimum of 10.5°C was recorded during the crop season.

Field Experiment

An experiment was carried out at Agronomy Research Farm, Punjab Agricultural University, Ludhiana during Rabi season of 2009-10.The soil was loamy sand with neutral pH of 8.1, low in organic carbon (0.24%) and available nitrogen (186 kg ha^{-1}), medium in available phosphorus (13.7 kg ha^{-1}) and high in available potassium (246.5 kg ha^{-1}).The treatments comprised of four methods of planting (Planting with Happy seeder, Rotavator, Zero tillage in the standing stubbles and conventional tillage after removal of paddy straw) and four N rates (Control,100,125 and 150 kg ha^{-1}) were laid out in split-plot design with three replications.

In case of zero tillage and happy seeder methods, the direct drilling was done in the field without any preparatory tillage with Pantnagar zero-till drill and happy seeder. In case of happy seeder, the loose straw of combine harvested rice was spread uniformly while planting of wheat. In conventional tillage, the field was prepared after pre-sowing irrigation at field capacity by two harrowing and two cultivations with a tractor drawn cultivator followed by planking. Once ploughing with rotavator for incorporation of paddy straw followed by seed broadcasting and again ploughing with rotavator for mixing the seed in the soil. The wheat cv. PBW 550 was sown on November 14, 2009 using 112.5 kg seed/ha in rows keeping plot size measuring 10 m x 2.5 m with zero till drill, happy seeder and on November 16, 2009 with conventional tillage and rotavator in the respective plots. The nitrogen was applied as per treatments. Half dose of nitrogen and full dose of phosphorus (62.5 kg $P_2O_5ha^{-1}$) and potassium (30kg K_2Oha^{-1}) was applied at sowing.The remaining half dose of nitrogen was broadcasted with first irrigation. The post-emergence spray of 2, 4-D @ 625g in 500 litres of water per hectare was done at 40 days after sowing for the control of weeds. The first post sowing irrigation was applied on December 11, 2009 and subsequent irrigations were applied on January 1, 2010, February 29, 2010, March 13, 2010 and March 24, 2010. The crop was harvested from the net plot of 7 m x 1.05 m on 14th April, 2010 (zero tillage and happy seeder) and 16th April, 2010 (rotavator and conventional tillage) for the record of per plot grain yield. Grain and straw samples were taken from the net plot for the analysis of nitrogen in grain and straw by The standard macro-Kjeldahl procedure. The soil samples from 0-15 cm depth

Table 3:Total input, direct, indirect, renewable, non-renewable and net gain energy under different treatments

Method of planting	Total input energy ($MJha^{-1}$)	Direct energy ($MJha^{-1}$)	Indirect energy ($MJha^{-1}$)	Renewable energy ($MJha^{-1}$)	Non-renewable energy ($MJha^{-1}$)	Net gain of energy ($MJha^{-1}$)
Happy seeder	12467.6	588.6	8054.01	7847.81	7147.11	102559.85
Zero tillage	12467.6	588.6	8054.01	7847.81	7147.11	110694.85
Rotavator	13189.4	1151.7	8210.81	7847.81	7867.01	104483.18
Conventional tillage	15682.9	1838.3	8401.84	7841.81	8744.84	115202.15
Nitrogen level (kg ha^{-1})						
Control	6694.7	1041.8	1827.9	1495.5	1374.2	69562.8
100	13651.3	1041.8	8782.65	8450.25	8328.95	109661.23
125	15164.5	1041.8	10297.65	9965.25	9843.95	120845.5
150	18297	1041.8	11812.65	11480.25	11358.95	132870.5

were collected before initiating the experiment. The mechanical and chemical analysis of soil samples was done to determine the texture and fertility of field experiments. The analysis of soil samples has shown that the soil of experimental field was loamy sand in texture with 78, 15 and 7 per cent of sand, silt and clay, respectively. The energy equivalent of inputs and outputs used in this study are presented in Table 1. Collected data on wheat yields and those inputs and outputs were used for energy efficiency parameters determination[3,11] as given below:

(EUE) Energy use efficiency: Energy output (MJ/ha)/energy input (MJ/ha)

(EP) Energy productivity: Grain yield (kg/ha)/energy input (MJ/ha)

(SE) Specific Energy: Energy input (MJ/ha)/grain yield (kg/ha)

(NEG) Net Energy Gain: Energy output (MJ/ha)– energy input (MJ/ha)

Indirect energy consisted of energy embodied in seeds, fertilizes, chemicals, machinery while direct energy included human labor and diesel used in the wheat production. Nonrenewable energy covered chemicals, fertilizers, machinery, diesel and renewable energy included seeds, human labor and fertilizer.

Results and Discussion

Input Energy Consumption

Total input energy use considerably varied with methods of planting and nitrogen rates (Table 3). The highest input energy consumed to produce of wheat under conventional tillage (15682.9 MJ ha^{-1}) followed by rotavator (13189.4 MJ ha^{-1}). The same and lowest energy consumed (12467.6 MJ ha^{-1}) when the crop was sown with direct drilling methods like zero tillage and happy seeder. The fertilizer and irrigation water showed the maximum share of energy consumption in wheat production (Table 2 and 3). The fertilizer and irrigation had 67.9 and 30.7 % share of the total input energy consumption in case of happy seeder and zero tillage but it was 64.2 & 29.0 and 54.0 & 24.4% rotavator and conventional tillage wheat, respectively and rest of the other inputs. The energy consumption increased with the increasing level of nitrogen up to the highest rate of 150 kg ha^{-1}. The highest energy consumption of 18297 MJ ha^{-1} was recorded with the application of 150 kg Nha^{-1} which was 63.4, 25.4, 17.1% higher than 0, 100 and 125 kg Nha^{-1}. The irrigation share of total energy consumption in control was 57.0% but fertilizer and irrigation share was 50.9 & 28.0, 55.9 & 25.2 and 54.6 & 20.9% in case of 100, 125 and 150 kg Nha^{-1}, respectively. From Iran[1] reported that average energy consumption for wheat production was 58367.69 MJha^{-1}. The similar results were reported by[13] and indicated that canola crop utilized a total of 30889.098 MJha^{-1} of which utilization of fertilizer energy was 38.93 % followed by electricity (27.62 %) and diesel fuel (20.085 %). It was reported that wheat production consumed a total 38356.39 MJha^{-1} of energy[12], which was mostly on fossil fuels. Fertilizer energy was the main energy input (38.45%). In Turkey found the energy requirement of sunflower was 18931.09 MJha^{-1} [18]. In this investigation found that the fertilizer was the maximum energy utilizing input (51.28%) followed by diesel fuel (28.55%). The results revealed that the total input energy consumption in sunflower production in Greece was 10.49 GJha^{-1}, with fertilizer being the major energy input[5].

Direct and Indirect Input Energy

The higher share of direct input energy of 13.83 and 9.90% of the total input energy was recorded in conventional tillage and rotavator compared to 5.46% each for zero tillage and happy seeder planted wheat (Table 2 and 3). The share of direct input energy varies with N rates. N has a negative relationship with direct input energy consumption. The higher direct input energy consumption of 14.99 % of the total input energy was recorded in the 0 kg Nha^{-1} compared to 7.47, 6.74 and 5.45%, respectively.

The indirect input energy consumption was higher under direct drilling methods which were 59.10, 59.10, 57.49% of the total input energy in happy seeder, zero tillage and rotavator, respectively compared to 50.69% for the conventional tillage (Table 2 and 3). The indirect input energy consumption showed a positive relationship with the use of nitrogen up to 125 kg Nha^{-1} further increase in N showed a negative relationship. The highest share of 67.99% of the total input energy was recorded with 125 kg Nha^{-1} compared to 66.35, 64.43 and 27.35% for the 150, 100 and 0 kg Nha^{-1}, respectively.

Renewable and Non-Renewable Input Energy

Renewable input energy had maximum share of direct drilling methods which was 57.24, 57.24 and 54.12% of the total input energy for happy seeder, zero tillage and rotavator compared to 46.57% for conventional tillage (Table 2 and 3). Renewable input energy had the same trend as the direct input energy with the varying rates of N. Renewable input energy of N showed the similar relationship as the indirect input energy. The maximum share of renewable input energy of 65.89% of the total input energy for 125 kg Nha^{-1} and lowest share was recorded of control (22.55%).

Non-renewable input energy consumption (Table 2 and 3) was highest in rotavator (54.29%) and conventional tillage (53.27%) compared to happy seeder (50.89 %) and zero tillage (50.89%). Non-renewable input energy had the similar trend as direct input energy and renewable energy with the application of N rates. N had a positive relationship with the non-renewable input energy. The lowest non-renewable input energy was recorded in the 0 kg Nha^{-1}.

Output Energy

Output energy varied significantly with the methods of planting and nitrogen rates. Wheat planted with zero tillage showed higher grain output energy which was significantly more than all the other methods of planting (Table 4). The application of 150 kg Nha^{-1} produced the significantly higher grain and straw output energy than the lower rates of N. The supply of 150 kg Nha^{-1} to the crop sown with zero tillage and happy seeder showed the highest grain output energy which was significantly more than the other treatment combinations. In case of straw, the significantly higher output energy showed the conventional tillage wheat as compared to other methods of planting. However, the interaction

Table 4:Total input and output energy under different treatments

Method of planting	**Grain energy equivalent (MJ ha^{-1})**				
	Nitrogen (Kgha^{-1})				
	0	**100**	**125**	**150**	**Mean**
Happy seeder	31900	52250	58170	77160	54870
Zero tillage	38580	63210	68340	78150	62070
Rotavator	33910	53190	60910	60040	52010
Conventional tillage	40480	50220	61990	72670	56340
Mean	36220	54720	62350	72010	
CD (p=0.05)	Planting method-4950	Nitrogen-1770	Planting method x N-3540		
	Straw energy equivalent (MJ ha^{-1})				
Happy seeder	34480	59940	70250	75960	60160
Zero tillage	46430	63810	64090	70040	61090
Rotavator	35580	71960	72850	82250	65660
Conventional Tillage	43670	78670	87440	88400	74620
Mean	40040	68670	73660	79160	
CD (p=0.05)	Planting method-4230	Nitrogen-2370	Planting method x N-4730		
	Total output energy equivalent (MJ ha^{-1})				
Happy seeder	66380	112190	128420	153120	115030
Zero tillage	85010	127020	132430	148190	123160
Rotavator	69490	125150	133760	142290	117670
Conventional tillage	84150	128890	149430	161070	130960
Mean	76260	123390	136010	151170	
CD (p=0.05)	Planting method-4590	Nitrogen-2070	Planting method x N-4140		

effect of method of planting and nitrogen was also significant. Conventional tillage wheat showed the similar straw output energy with the use of 125 and 150 kg Nha^{-1} and it was significantly more than the other treatment combinations. Total output energy of grain and straw was recorded significantly more from the wheat planted with conventional tillage as compared to other methods of planting. Total output energy was increased significantly with the increase in N from 0 to 150 kg Nha^{-1}. The interactive effect showed that conventional tillage wheat with the use of 150 kg Nha^{-1} produced the highest total output energy.

Net Gain of Energy

The maximum net gain of energy of 115202.15 MJha^{-1} was observed in conventional tillage which was 10.97, 9.30 and 3.91% more than happy seeder (102559.85 MJha^{-1}), rotavator (104483.18 MJha^{-1}), and zero tillage (110694.85 MJha^{-1}), respectively (Table 3). The higher net gain under the conventional tillage was due to the more output energy in straw as compared to grains. Net gain of energy was increased with each increment of N and the maximum of 102559.85 MJha^{-1} was recorded with 150 kg Nha^{-1} which was 47.65, 17.47 and 9.05 % more than 0 (69562.80 MJha^{-1}), 100 (109661.23 MJha^{-1}) and 125 (120845.50 MJha^{-1}), kg Nha^{-1}. In Iran reported that average energy about 8755.1 MJha^{-1} of total energy could be saved while holding the constant level of wheat yield[1] in Iran. In another study reported that net energy gain in sunflower production was 36.87 GJha^{-1} [5].

Energy Use Efficiency

The energy use efficiency varies with the methods of planting and it was obtained 10.48, 9.44, 9.11 and 8.90 from the zero tillage, happy seeder, rotavator and conventional tillage wheat (Table 5). It shows that direct drilling methods are more efficient than the traditional method of planting. The nitrogen use showed negative relation with the energy use efficiency. The maximum was recorded under the control and lowest at 150 Kg Nha^{-1}. It may be due to the immobilization or leaching losses of a higher rate of nitrogen than a lower rate. The output-input energy ratio varies with the location. It was found to be 3.13 in wheat from Ardabil Province of Iran[12], 5.39 in rainfed wheat from India[8]. In another reported that energy ratio in sunflower production was 4.5 [5]. To compare the work of various workers, it shows the direct drilling methods are more efficient in energy use efficiency compared to conventional method.

Energy Productivity

Energy productivity had the similar trend as nitrogen use efficiency (Table 5). The highest was recorded of 0.35 kgMJ^{-1} with zero tillage followed by happy

Table 5:Energy use efficiency, Energy production, Energy specific NPK energy equivalent in grain and straw under different treatments

Treatment	Energy use efficiency	Energy production (kgMJ^{-1})	Energy specific (MJkg-1)	NPK energy equivalent in grain (MJha^{-1})	NPK energy equivalent in straw (MJha^{-1})	Total NPK energy equivalent in grain and straw (MJha^{-1})
Method of planting						
Happy seeder	9.44	0.31	3.31	4439.5	2403.5	6843
Zero tillage	10.48	0.35	2.88	5436.4	2992.4	8428.8
Rotavator	9.11	0.28	3.65	4700.3	2171.1	6871.4
Conventional tillage	8.9	0.26	3.96	5157.4	2749.3	7906.7
Nitrogen level (kg ha^{-1})						
Control	11.46	0.37	2.73	2741.1	1188.2	3929.3
100	9.04	0.27	3.7	4546.7	2329.2	6875.9
125	8.96	0.28	3.59	5471.5	3072.4	8543.9
150	8.46	0.28	3.78	6971.6	3728.3	10699.9

seeder (0.31 $kgMJ^{-1}$), rotavator (0.28 $kgMJ^{-1}$) and conventional tillage (0.26 $kgMJ^{-1}$). It showed that the direct drilling methods like zero tillage and happy seeder are more efficient methods for producing more with less energy as compared to rotavator and conventional tillage. Energy productivity was maximum under control (0.37 $kgMJ^{-1}$) and a further increase in nitrogen from 100 to 150 kg Nha^{-1} decreased the energy productivity from 0.27 and 0.28 $kgMJ^{-1}$, respectively. It could be due to the immobilization or leaching losses of a higher rate of nitrogen than a lower rate. Energy productivity of wheat is varied with the location. Energy productivity of wheat was recorded 0.16 $KgMJ^{-1}$ from Ardabil Province of Iran[12]. Our results are also showed higher energy productivity with the direct drilling methods which are more efficient than the traditional method.

Energy-Specific

In this case, trend was reversed; the lowest energy specific was recorded with zero tillage and highest with conventional tillage (Table 5). It shows that the wheat sown with conventional tillage utilized more energy to produce one kilogram of grain as compared to other methods of planting. However, the application of nitrogen from 100 to 150 kg ha^{-1} consumed more energy for the production of wheat over the control. It shows that higher production of wheat can be obtained with the use of higher energy in the form of fertilizer.

NPK Energy Equivalent

NPK energy equivalent in grain, straw and total equivalent energy in biomass were varied with methods of planting and nitrogen rates (Table 5). Energy equivalent in grain was highest under zero tillage followed by conventional tillage, rotavator and happy seeder. However, in case of straw the higher energy equivalent in zero tillage followed by conventional tillage, happy seeder and rotavator. The similar trend was observed in NPK energy equivalent in biomass as the energy equivalent obtained in grains. The NPK energy equivalent showed a positive relationship with the application of nitrogen. The energy equivalent of NPK in grains, straw and biomass was increased with the increase in nitrogen rate from 0 to 150 kg Nha^{-1}. The highest NPK energy equivalent was recorded with 150 kg Nha-1 in grains, straw and biomass.

Conclusion

Wheat planted with direct drilling methods like HS, ZT and RT under irrigated conditions consumed a total input energy of 12467.6, 12467.6 and 13189.4 $Mjha^{-1}$ compared 15682.9 $MJha^{-1}$ with conventional tillage. N showed a positive relationship with the use of input energy and highest consumed at 150 kg Nha^{-1}. The major energy use inputs were fertilizer and irrigation in wheat production. These inputs had the share of total energy consumption of 98.6, 98.6 and 93.2 and 78.4% in HS, ZT, RT and CT wheat and 78.9, 81.1 75.5% for 100, 125 and 150 kg Nha^{-1}. The highest total output energy equivalent was recorded in CT and with 150 kg Nha^{-1}. However, the supply of 150 kg Nha^{-1} to the crop sown with zero tillage and happy seeder showed the highest grain output energy which was significantly more than the other treatment combinations. The higher output: input ratio and energy productivity and lower energy specific were recorded under direct drilling methods compared to traditional method. A total NPK energy equivalent was observed in ZT and with 150 kg Nha^{-1}. However, a higher net gain of energy was found in CT and with 150 kg Nha^{-1}. The use of conservation agriculture practices like zero tillage and happy seeder with 150 kg Nha^{-1} for wheat production found to be more efficient and to improve the utilization of natural and energy resources.

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