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Research Article

ENERGY REQUIREMENT AND ECONOMIC VIABILITY OF RAISED BED PLANTERS FOR WHEAT PRODUCTION IN VERTISOL

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Abstract- The aim of this research was to examine the energy requirements of the inputs and output as well as economic viability of raised bed planters with different configuration of beds for wheat production in Vertsiol. This experiment compared three raised bed planters /seed-drill with conventional seed cum fertilizer drill for wheat in a split plot design with three replications. The field was arranged in two tillage levels for seed bed preparation as main treatment *i.e.*, T_1 - 1 × Cultivator + 1 × Disc Harrow and T_2 - 1 × Cultivator + 2 × Disc Harrow and four sub-main treatment of sowing practices as S_1 – Jawahar raised bed seed drill (120 cm wide, 5 rows per raised bed), S_2 – National raised bed planter (70 cm wide, 3 rows per bed), S_3 – Pantnagar raised bed planter (125 cm wide, 5 rows per bed) and S_4 – Conventional seed-cum-fertilizer-drill. The source wise energy was minimum (12658.5 MJ/ha) in treatment S_1-T_1 and maximum (14007.1 MJ/ha) in treatment S_1-T_2 whereas operation wise energy was minimum (5488.9 MJ/ha) in treatment S_4-T_1 and maximum (5873.0 MJ/ha) in treatment S_1-T_2 On the basis of study it can be concluded that National Raised Bed Planter (S_2) requires less cost of operation than other raised bed planters for wheat cultivation and gave the higher grain yield when operated in tillage level T_2 and gave the highest net return (66252.5 Rs/ha).

Keywords- Energy, source wise energy, operation wise energy, economic viability

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Introduction

In the present scenario, agriculture sector is under increasing pressure to sustainably produce higher yields with less inputs, due to declining land and water productivity potential, increasing cost of production, variable market conditions and increasing world population [1]. Effective energy use in agriculture is one of the conditions for sustainable agricultural production, since it provides financial savings, fossil resources preservation and air pollution reduction [2]. The energy required in agricultural operations, mainly depends on fossil fuels/natural resources which are a scarce commodity. Today's real agricultural challenges are resource fatigue with declining factor productivity, decreasing human resources and their rising costs and socioeconomic changes [3, 4 and 5]. Wheat (*Triticum aestivum* L.) is one of the premier cereal crops of the world. In India, it is the second major food crop after rice. India is occupying about 30.23 mha cultivated area and annual production is about 93.50 mT with an average productivity of 3,177 kg/ha [6]. India is the largest wheat producing country and contributing about 13.10 % global wheat production. In India, Madhya Pradesh is the third largest wheat producing state after Uttar Pradesh and Punjab, with the average area, production and productivity are 5.91 mha, 18.41 mT and 3115 kg/ha, respectively [7]. Mechanization level, energy input and agro-climatic zone constitute the most pertinent set of factors responsible for the higher production of wheat. For wheat production various energy sources ranging from human and animal power to power of heavy machinery has used as an input energy sources and final yield vary with each system and ultimately influencing the output–input ratio [8]. Sowing techniques and type of seeding machines play an important role in seed placement and seedling emergence which ultimately affect crop growth and grain yield [9]. Raised beds have proven to be an excellent option for wheat and are widely used in agriculture in various countries [10].

Raised bed (RB) farming systems combine most of the elements of conservation agriculture and have produced encouraging production results under various environmental conditions. RBs offer the opportunity of reducing field compaction and restoring physically degraded soil structure, as well as, the potential to reduce irrigation water and increase crop yield while reducing the risk of water logging [11]. In raised bed planting system, fields are prepared conventionally and beds are formed manually or by tractor drawn raised bed formers or raised bed planter/seeder. Raised bed planters/seeder are used for preparing beds and sowing simultaneously, in this crop are planted in multiple rows on top of the bed and irrigation is applied in furrows made in between the bed, and by lateral movement through the soil water is reaches to the plants [12]. Bed planting has also been found to show improved water distribution and efficiency, fertilizer use efficiency and reduced weed infestation [13]. This technique also requires reduced seed rate as compared to flat sowing without sacrificing crop yield. Bed planting also ensures better crop stand and yield by improvement of root proliferation [14]. It has also been reported that this system is more resistant to lodging than the crop sown on flat fields for wheat crop [15]. In adverse climate condition, excess rainwater drained out from the field through furrows to minimize its harmful effect on the crop [12]. In the last decade, yield of wheat has increased manifold, which leads to high energy inputs use [16]. In field farmers used the various inputs *i.e.,* tractor, agricultural machinery, diesel, electricity, seed, fertilizer, plant protection chemicals, farm yard manure, irrigation water etc in improper or excessive manner to get the high crop production. Efficient use of these inputs helps to earn higher production and productivity which contributes to economy, and competitiveness of agriculture sustainability to rural living [17]. Raised bed planting shows the better option for efficient use and minimal wastage of agricultural inputs and to get higher production with the given energy.

The present study was undertaken to estimate and compare the energy requirements for the production of wheat with raised bed planters having different configuration and conventional seed cum fertilizer drill with respect to technology level and energy input. The reason behind selecting the wheat crop was that it is the major cereal crop grown in Madhya Pradesh, India.

Materials and Methods

Study site description: This study was established at experimental station of Jawaharlal Nehru Krishi Vishwa Vidyalaya Jabalpur (M.P.) during 2012-13. The university is located at 23°13'15.32" N* longitude and 79°57' 50.82" E* latitude and 390 m above MSL. The soil of the experimental field was classified as vertisol which contains sand-29.10%, silt-20.15% and clay-50.75% with pH 7.5- 8.0 and bulk density 1.1.-1.25 kg/m^3.

Experiment layout and treatments: This experiment compared three different raised bed planters /seed-drill with conventional seed cum fertilizer drill for wheat in a split plot design with three replications. The field was arranged in two tillage levels for seed bed preparation as main treatment *i.e.,* T_1 - 1 × Cultivator + 1 × Disc Harrow and T_2 - 1 × Cultivator + 2 × Disc Harrow and four sub-main treatment of sowing practices are S_1 – Jawahar raised bed seed drill (120 cm wide, 5 rows per raised bed), S_2 – National raised bed planter (70 cm wide, 3 rows per bed), S_3 – Pantnagar raised bed planter (125 cm wide, 5 rows per bed) and S_4 -Conventional seed-cum-fertilizer-drill. The experiment was conducted in a field of 35m X 35m size. The field was divided in 24 sub plots and unit plot size was 24 m^2. Wheat (GW-273) was sown at the rate of 100 kg/ha on 20 October 2012 and harvested on 30 April 2013. The recommended dose of fertilizer in the ratio of 120:60:40 of Nitrogen: Phosphorous: Potassium per hectare was applied in the field. The phosphorous, potassium is wholly applied during sowing and nitrogen is applied in dozes 30% during sowing as basal doze and 30% after three weeks and rest of 40% after five weeks as top dressing.

Energy Requirement: The energy use pattern for production of wheat crop were determine according to sources and operation to be used at various treatments. The source wise energy includes human, diesel fuel, tractor, electricity, seed, farm yard manure, fertilizer, chemical and machinery as an input whereas operation wise energy shows energy consumed at various operation *i.e.,* tillage, sowing, inter-culture, irrigation, top dressing, harvesting and threshing. To estimate the output and input energy, physical quantities of each ingredient used as input and output were converted into energy equivalents (MJ/ha) by multiplied them with their energy conversion factor. The energy equivalents of various inputs used in cultivation of wheat crop are present in [Table-1].

(a) Jawahar raised bed seed drill (b) National raised bed planter

(c) Pantnagar raised bed planter (d) Conventional seed cum fertilizer

Fig-1 View of different sowing equipment operated in the field

Table-1 *The energy equivalents of various agriculture inputs.*

Energy Sources	Units	Equivalent Energy (MJ/unit)	Reference
Human			
Man	h	1.96	[17, 18,19]
Woman	h	1.57	[17, 18]
Agricultural Machinery	h	62.7	[17, 20]
Diesel	l	56.31	[17, 20]
Fertilizer			
Nitrogen (N)	Kg	60.6	[17]
Phosphorus (P_2O_5)	Kg	11.1	[17]
Potassium (K_2O)	Kg	6.7	[17]
Farm Yard Manure	Kg	0.3	[17]
Electricity	kWh	11.93	[20]
Chemical			
Superior (need dilution)	l	120	[17, 18]
Inferior (not need dilution)	Kg	10	[17, 18]
Seed (Wheat)	Kg	14.7	[17, 18, 20]
Straw	Kg	12.5	[17, 20]

Results and discussion

Grain yield Attributes:

The grain yield per hectare of four different sowing machines was significantly ($P \geq 0.05$) influenced by tillage levels. The data presented in [Table-2] shows that grain yield in tillage level T_2 of all four machines significantly higher than the grain yield in tillage level T_1. On the basis of various sowing practices average grain yield were found to be 43.2, 47.3, 40.5 and 42.2 q/ha in S_1, S_2, S_3 and S_4 respectively. While comparing tillage levels the average yield 42.2 q/ha was found in T_1 and 44.4 q/ha in T_2. The straw grain ratio in different treatments were measured and among all the treatments highest straw-grain ratio was observed in treatment S_2-T_2 (1.31:1). The weight of 1000 grain was also measured under all the treatments, and the highest weight was found in treatment S_2-T_2 (43.4g) which shows the health of germinated seeds and lowest in S_3-T_1 and S_4-T_1 (38.7g).

Table-2 *Crop yield parameter under different treatments*

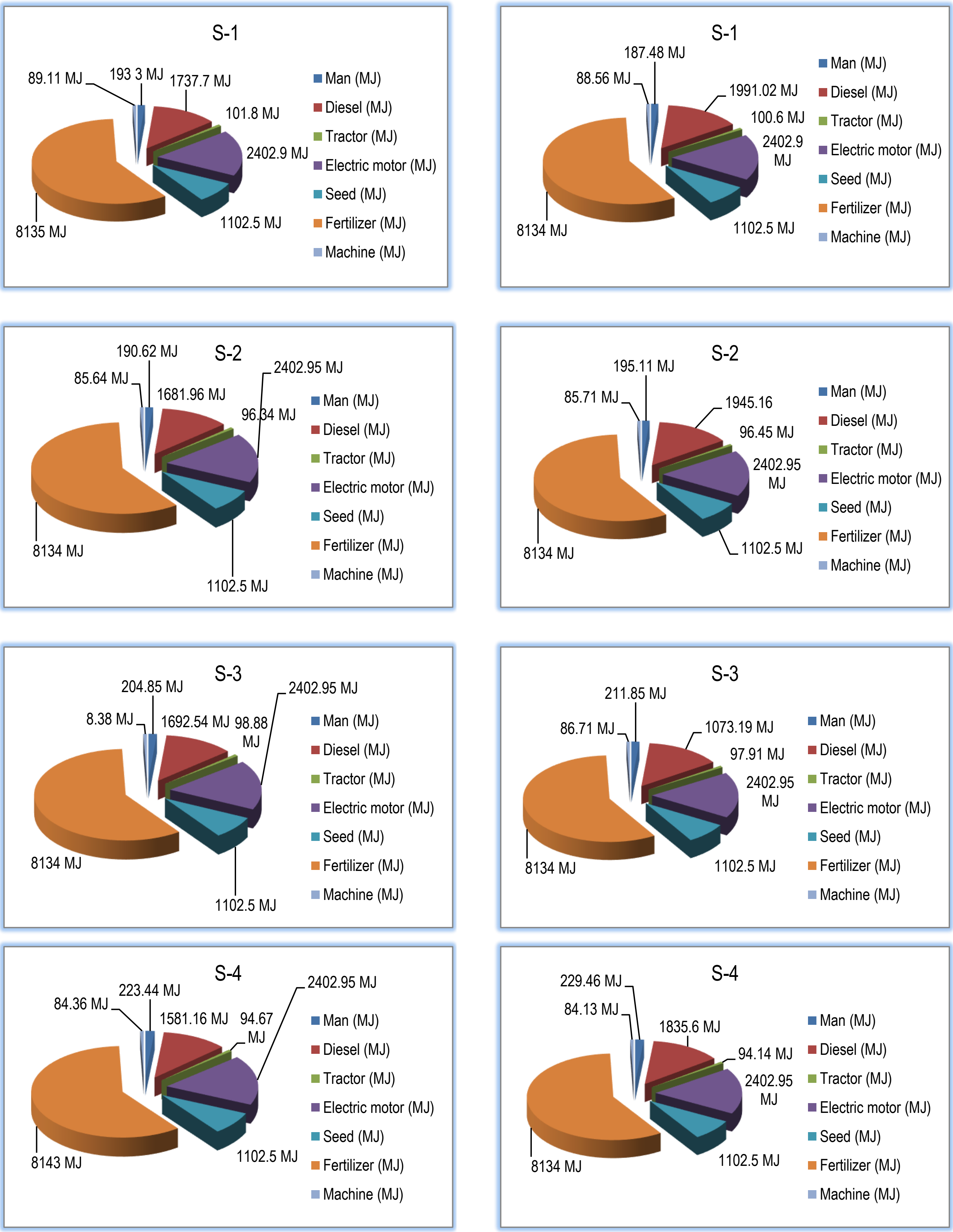
Sub Treatment	Crop Yield Parameter – Main treatment: T_1			T_2		
	Grain Yield (kg/ha)	Straw Grain Ratio (%)	1000 Grain weight (g)	Grain Yield (kg/ha)	Straw Grain Ratio (%)	1000 Grain weight (g)
S_1	42.6	1.21	38.9	43.8	1.23	40.3
S_2	45.1	1.23	41.8	49.5	1.31	43.4
S_3	40.2	1.24	38.7	40.8	1.27	40.3
S_4	40.9	1.22	38.7	43.5	1.23	40.1
		$(S \times T)_1$			$(S \times T)_2$	
S.Em	1.36	0.03	0.78	1.66	0.02	0.67
C.D. (5%)	5.32	0.12	3.07	4.8	0.07	1.95

Energy Requirement

Source wise energy (MJ/ha) consumption under different treatments

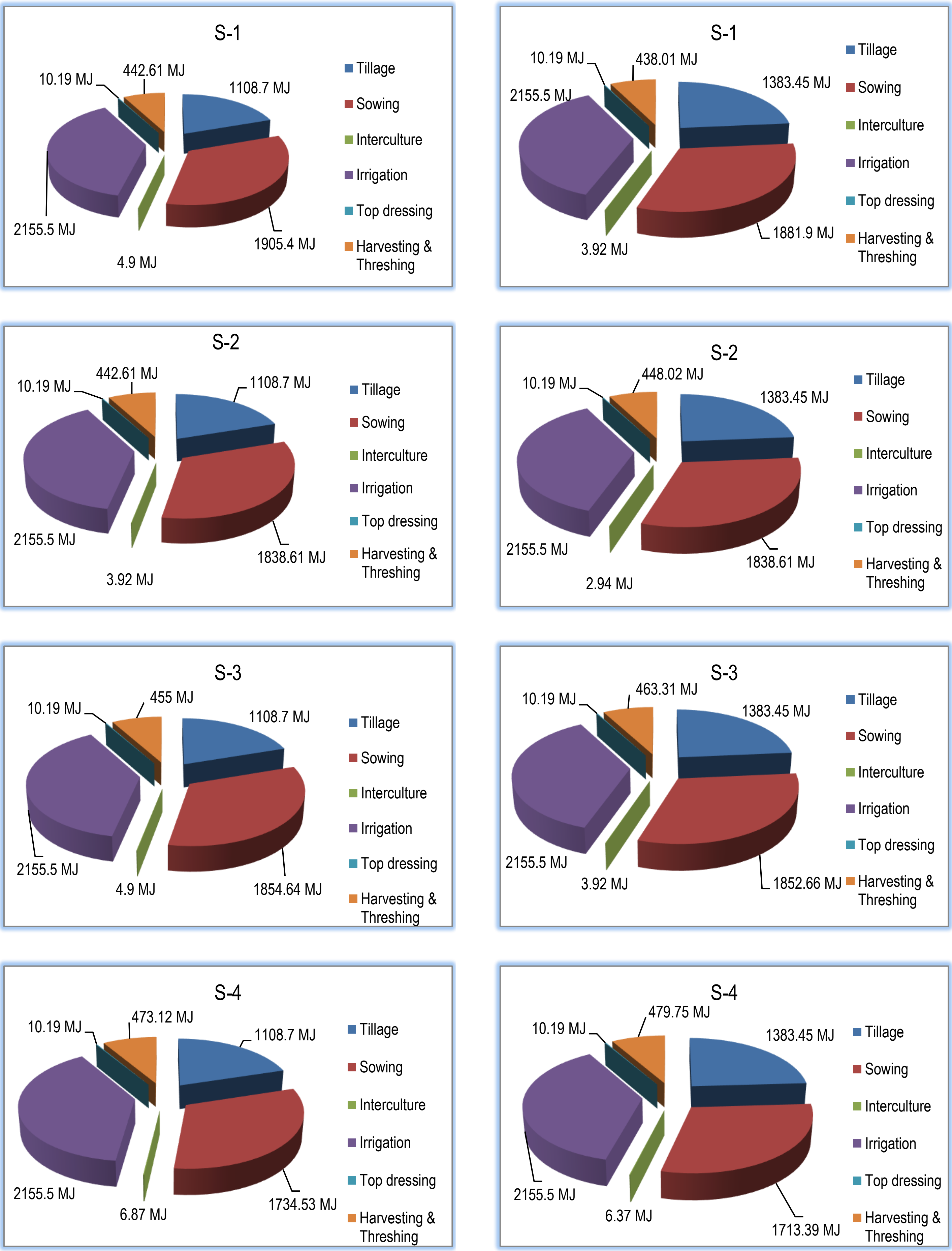
Source wise energy consumption *i.e.,* human, diesel, tractor, machine, electric motor, seed and fertilizer under different treatments were measured and the energy consumed by each source were presented in [Fig-2]. The energy consumed by electric motor, seed and fertilizer was same in all treatments because of same irrigation schedule, seed and fertilizer rate in all the treatments.

The source wise energy consumption for S_3 (12658.5 MJ/ha) in treatment T_1 was found to be minimum whereas maximum energy was consumed in S_1 (14007.1 MJ/ha) and S_3 (14009.1 MJ/ha) in tillage level T_2. The individual energy source like man energy was lowest in S_1-T_2 (187.48 MJ/ha) and highest in S_4-T_2 treatment (229.46 MJ/ha), Diesel energy was lowest in S_4-T_1 (1581.16 MJ/ha) and highest in



Treatment -1 Treatment - 2

Fig-2 Source wise energy (MJ/ha) consumption for different sowing machinery under two tillage level



Treatment – 1 Treatment – 2

Fig-3 Operation wise energy (MJ/ha) consumption for different sowing machinery under two tillage level

S_1-T_2 (1991.02), tractor energy was lowest in S_4-T_2 (94.14/ha) and highest in S_1-T_1 (101.8 MJ/ha) similarly machine energy was lowest in S_2-T_1 (85.64 MJ/ha) and highest in S_1-T_1 (89.11 MJ/ha)

Operation wise energy (MJ/ha) consumption under different treatments

The operation wise energy consumption [Fig-3] for sowing machine S_1, S_2, S_3 and S_4 in tillage level T_1 were 5627.4, 5559.6, 5588.9 and 5488.9 MJ/ha whereas in tillage level T_2 it was 5873.0, 5838.7, 5859.0 and 5748.6 MJ/ha respectively. The energy consumption in irrigation and top-dressing operation were same in all treatments which are 2155.6 and 10.19 MJ/ha respectively because of same quantity and schedule. The energy consumed in sowing operation was highest in case of S_1 1905.4 MJ/ha in tillage level T_1, while lowest energy consumed by S_4 in both the tillage level, *i.e.,* 1734.5 MJ/ha in T_1 and 1713.3 MJ/ha in T_2. The maximum energy in intercultural operation was observed in S_4 (6.87MJ/ha) treatment in tillage level T_1 whereas minimum energy was observed in S_2 (2.94 MJ/ha) treatment in tillage level T_2. Similarly, energy consumed in harvesting and threshing operation was highest in S_4 in both tillage level and lowest in S_1 in tillage level T_2.

Cost of Operation

The cost of operation (seed bed preparation + sowing) was found to be highest in S_1-T_2 (3572.7 Rs/ha) treatment and lowest in S_4-T_1 (2713.9 Rs./ha) treatment whereas total cost of production was found to be highest in case of S_3 (8264.7 Rs/ha) and S_4 (8331.8 Rs/ha) in tillage level T_2 and lowest in S_2 (7427 Rs/ha) in tillage level T_1. The benefit cost ratio of S_2 (8.28:1) in tillage treatment T_2 observed highest while in S_3 (6.40:1) treatment with tillage level T_2 it observed lowest. The highest net return (income) was achieved in S_2 (66252.5 Rs/ha) with tillage level T_2 and lowest in S_3 (52472.6 Rs/ha) with tillage level T_1.

Conclusion

This research was carried out to evaluate the performance of different raised bed planter/seed drill for cultivation of wheat crop in vertisol. On the basis of results, it was found that the average grain yield was 43.2, 47.3, 40.5 and 42.2 q/ha in S_1, S_2, S_3 and S_4 treatments respectively. While comparing tillage methods the average yield 42.2 q/ha was found in T_1 and 44.4q/ha was found in T_2. Therefore, it can be said that there was significant effect of sowing method on yield and strong correlation was observed between yield and tillage level. The source wise energy was minimum (12658.5 MJ/ha) in treatment S_1-T_1 and maximum (14007.1 MJ/ha) in treatment S_1-T_2 whereas operation wise energy was minimum (5488.9 MJ/ha) in treatment S_4-T_1 and maximum (5873.0 MJ/ha) in treatment S_1-T_2. On the basis of study, it can be concluded that National Raised Bed Planter (S_2) requires less cost of operation than other raised bed planters for wheat cultivation and gave the higher grain yield when operated in tillage level T_2 and gave the highest net return (66252.5 Rs/ha).

Research Category: Energy consumption and Economic viability

Abbreviations:

C.D. Coefficient of Deviation
E* East
N* North
GW-273 Wheat variety
N Nitrogen
K_2O Potassium oxide
P_2O_5 Phosphorus pentoxide
M.P. Madhya pradesh
MSL Mean Sea Level
RB Raised bed
S.Em Standard Mean Error
S_1 Jawahar raised bed seed drill (120 cm wide, 5 rows per raised bed)
S_2 National raised bed planter (70 cm wide, 3 rows per bed)
S_3 Pantnagar raised bed planter (125 cm wide, 5 rows per bed)
S_4 Conventional seed-cum-fertilizer-drill
T_1 1 × Cultivator + 1 × Disc Harrow
T_2 1 × Cultivator + 2 × Disc Harrow

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