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Assessment of plot size and tillage pattern on the economy of fuel consumption in land preparation using tractors and power tillers at different soil moisture conditions in Dinajpur District, Bangladesh

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Abstract

The study was conducted to determine the most frequent class sizes of land area cultivated by farmers in Dinajpur District to conserve fuel consumption for tillage operations using tractors and power tillers. From 6 different unions of Birganj Upazilla, Dinajpur, total 270 plots 18 different villages were studied 15 plots from each village. From the studied areas, it was found that plot sizes varied from 75.44m^2 to 2162.09m^2. However the most frequent sizes were found between 101m^2 and 700m^2 coverings almost 88% when grouped into size classes at 100m^2 interval. Also different shapes of plots were found from the study such as rectangular, trapezoidal, pentagonal, hexagonal, octagonal, square, parallelogram etc., however, rectangular, trapezoidal, pentagon and hexagonal shapes covered almost 90% of the plot area measured. In case of fuel consumption tests, second and third tillage were found to consume less fuel than the first one. Also lengthwise tilling operations were found to consume less fuel than widthwise operation.

Keywords: Tillage pattern, Land size, fuel consumption, Tractor, Trapezoidal.

Introduction

Tillage operation is one of the most important operations for successful crop production. It is required for control of weeds, to pulverize the soil, to aerate the soil, to destroy harmful insects and pests, to loosen the soil, to mix necessary manures, fertilizers and soil amendments to the soil, and ultimately to prepare a good seedbed or a root bed[1]. Tillage consumes the largest amount of power required for total operations for a crop production. According to numerous opinions conventional tillage is essential foundation for stable arable crops and it is also known as one of the greatest energy and labour consumer[2]. Stroppel[3] mentioned that 85% of the fields in Central Europe are tilled in conventional tillage system. In Bangladesh more than 95% of the land is tilled in conventional way. The traditional way of tillage operation in Bangladesh is to use animal power with traditional country plow. This requires enough time to till the land and to prepare it for crop planting. Sometimes delay of preparing the land causes reduced crop yields due to late planting[4]. Late sowing is one of the major constraints in wheat cultivation. Wheat yield is reduced by 1.3% per day for late sowing after November 30. Yet in Bangladesh, more than 50% of the growers sow wheat after this date. The identical major causes for late sowing are long turn-around time, shortage of draft power and more number of ploughing and cross ploughing for land preparation[5]. Report shows that by 2004 almost 74% of the land was tilled by power tillers[6]. In many of the areas of Bangladesh, the use of animal power for tillage purposes are almost removed.

The latest report on Farm Machinery states the number of Tractors and Power tillers as 20,000 and about 3,00,000 respectively in Bangladesh. The latest census of draft power is not properly known but decreased remarkably due to reasons stated above. Due to decrease in draft animals, shortage of draft power needed for optimum crop production, the increased use of tractors and power tillers were obvious. The efficiency of tillage operations in respect of fuel consumption is urgent as the fuel price is going up continuously and the land cultivation is getting dependent every day on tractors and power tillers[7].

To use tractors or power tillers for tillage operations, huge amount of fuel is consumed. Tractor fuel is the single largest use of energy in agriculture[8]. It is important to optimize the amount of fuels used due to the continuous rising of fuel price. The amount of fuels used also depends on the size of power units, the moisture content of the soil and the pattern of land sizes. If the land sizes are small, using bigger sizes of power units will cause a reasonable amount of turning loss and wastage of valuable fuels. On the other hand using a small power unit (PT) for a big size land will cause wastage of valuable time and labour causing decrease in potential crop yield. Tillage efficiency varies from 75 to 90%. Turns at the ends or corners of a field represent a loss of time that is often of considerable importance, especially for short fields. The turning loss increases with the narrowness of the field, the less amount of turning space in the headlands, the roughness of the turning area and the increase in implement width[1].

Some literature is available in foreign journals and books of Tillage and Farm Machinery. Those reports and results may not be applicable directly for Bangladesh due to land size, soil type, crops, climatic and other socio-economical conditions. Not enough literature is available in this area of research and not enough research work has also been done in this area in Bangladesh. To optimize the most economic fuel use, it is important to find out the best land use pattern and the best tillage pattern. The land use pattern is not known from agricultural production point of view, particularly from the point of view of tillage efficiency. If the fuel use efficiency in tillage operations could be increased, more land could be brought under cultivation and get more yield which is an urgent need for the country for the same energy input. Therefore, this project is aimed at finding the best land use pattern at different moisture content of soil and best tillage pattern for most economic fuel consumption. The main objective is to identify the major land size and shape pattern in Northern districts of Bangladesh and find most economical tillage pattern for fuel economy at different soil moisture conditions using power tillers. The specific objectives are to study the land size and shape pattern in Dinajpur district of Bangladesh; to measure time and fuel consumption to till sample land for different land size and shapes at different moisture levels using power tillers; to compare the time and fuel consumption of different types of land and soil moisture conditions.

Materials and methods

Location of the research work: The research work was conducted in Birganj Upazilla of Dinajpur District, Bangladesh. Map of Birganj Upazilla as shown in Figure-3.

Experimental design of the research work: Plot sizes of cultivable land were measured from 6 unions of the above upazilla. Three villages from each union were selected and 15 adjacent plots from each village were selected for the measurement. The experimental set-up as shown in Table-1. The unions and the villages were selected in such a way that they approximately represented the whole upazilla in respect of plot sizes of cultivable land in an average.

Measurement of plot size and shape: The size and shape of each plot was measured and recorded manually using measuring tape. The length and width of the plots at different corners were measured to get the approximate close shape of the land. In case of big size plots, several measurements in the length and width were taken to minimize the error in assessing the actual shape of the land and to include the changing shape of the land. While measuring each plot, a rough sketch of the shape to scale was drawn on the note book to locate the position of the plots in respect of each other. Ultimately, when 15 neighbouring plots were measured, recorded and plotted in paper we got some clear picture of the plots size, shape and location in respect of each other. Later on, from the recorded field data, exact plotting in approximate scale was done on the graph paper to find the approximate exact shape of the land and these were preserved for further use. From the graphs and recorded data, different shapes and sizes of plots were categorized according to frequency distribution. From the frequency distributions, most frequent plot sizes and shapes were selected representing maximum land sizes and shapes. The maximum representative land sizes and shapes were then selected for testing of fuel consumption using tractors and power tillers. Different plot size and shapes in different villages of Birgonj Upazilla, Dinajpur as shown in Figure-1 and 2.

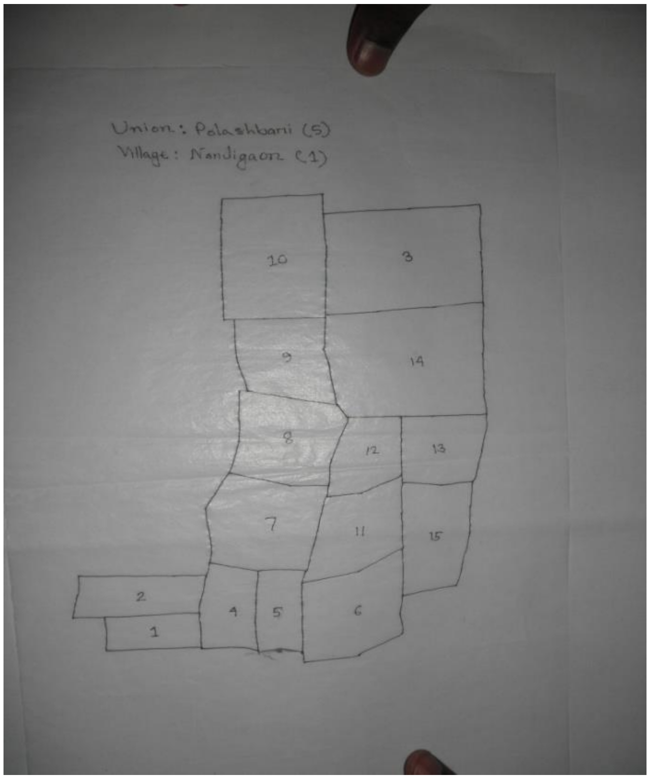
Table-1: Experimental set up of the research works. Upazilla: Birgonj, Dinajpur

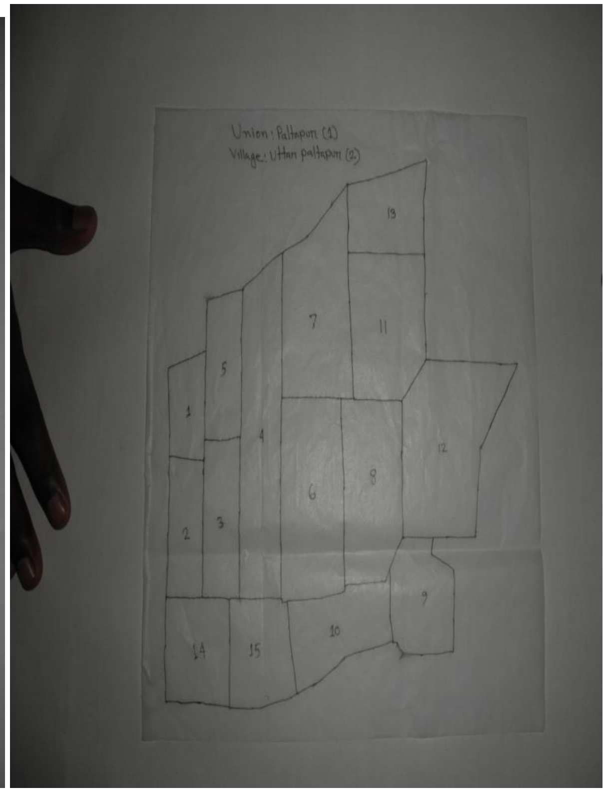
Name of the unions	Name of the villages	No. of plots measured
1. Paltapur	1. Ghoraghat 2. Uttar paltapur 3. Kajal	15 15 15
2. Bhognagar	1. Kabirajpurhat 2. Krishnapur 3. Chaolia	15 15 15
3. Satar	1. Chakpatla 2. Chowpukuria 3. Prannagar	15 15 15
4. Nijpara	1. Prembazar 2. Kolyani 3. Doriapur	15 15 15
5. Palashbari	1. Nandiagaon 2. Madati 3. Brahmanvita	15 15 15
6. Moricha	1.14 Hat Kalibazar 2.Golapgonj 3.Mohadevpur	15 15 15

Fuel Consumption tests: From the most frequent plot sizes and shapes, a limited number of plots were tilled using tractors and power tillers. While testing for fuel consumptions, the land was first measured for length and width. The fuel tank of the power tiller was filled up with fuel placing in an approximate level ground. The plot was then ploughed and time recorded. After plowing, the fuel tank was filled again and the amount of fuel required was recorded for refilling. This was the fuel consumption for that particular plot size. The operation was repeated for second plowing using different gear setting and the time and fuel consumption recorded again.

Results and discussion

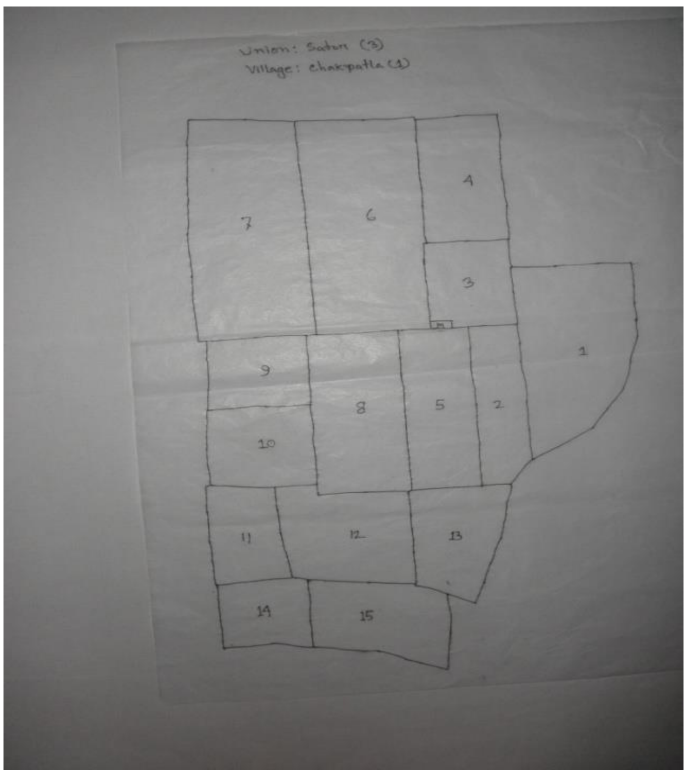
The results obtained regarding the size and shapes of different plot sizes measured in 18 villages of 6 unions of Birganj Upazilla of Dinajpur Districts. It also covers the limited results obtained from the fuel consumption study of some selected plot sizes within the most frequent size and shapes from the study. Measurement of length, width and area together with the shapes of the plots were done for 270 plots altogether from the above mentioned unions and villages. The size classes of the measured plots are shown in Figure-4.

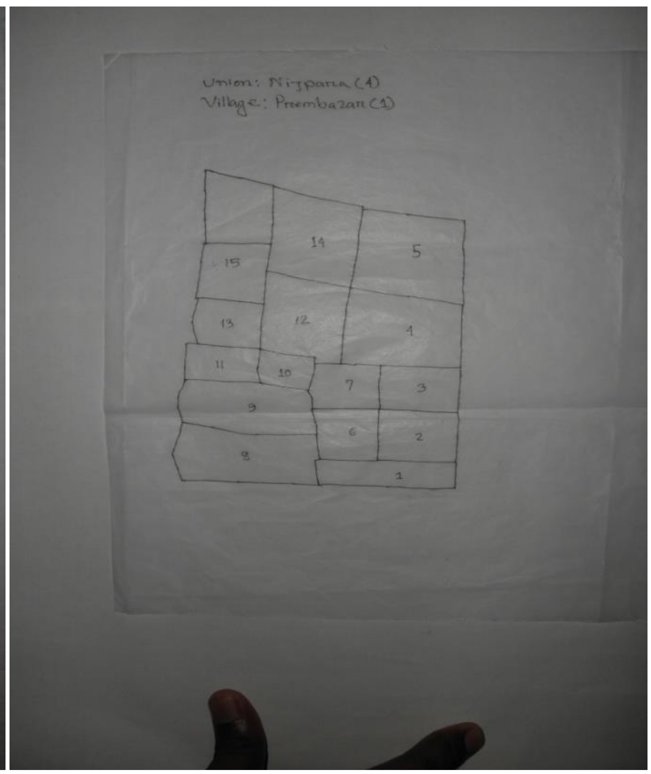




a. Village: Nandigram, Union: Palashbari

b. Village: Uttor Paltapur, Union: Paltapur





c. Village: Chalkpatla, Union: Sator

d. Village: Prembazar, Union: Nijpara

Figure-1: Showing different plot shapes in different villages of Birgonj Upazilla, Dinajpur.

Figure-2: Some shots taken from various field to the field sizes and shapes.

Figure-3: Map of Birganj Upazilla showing research area.

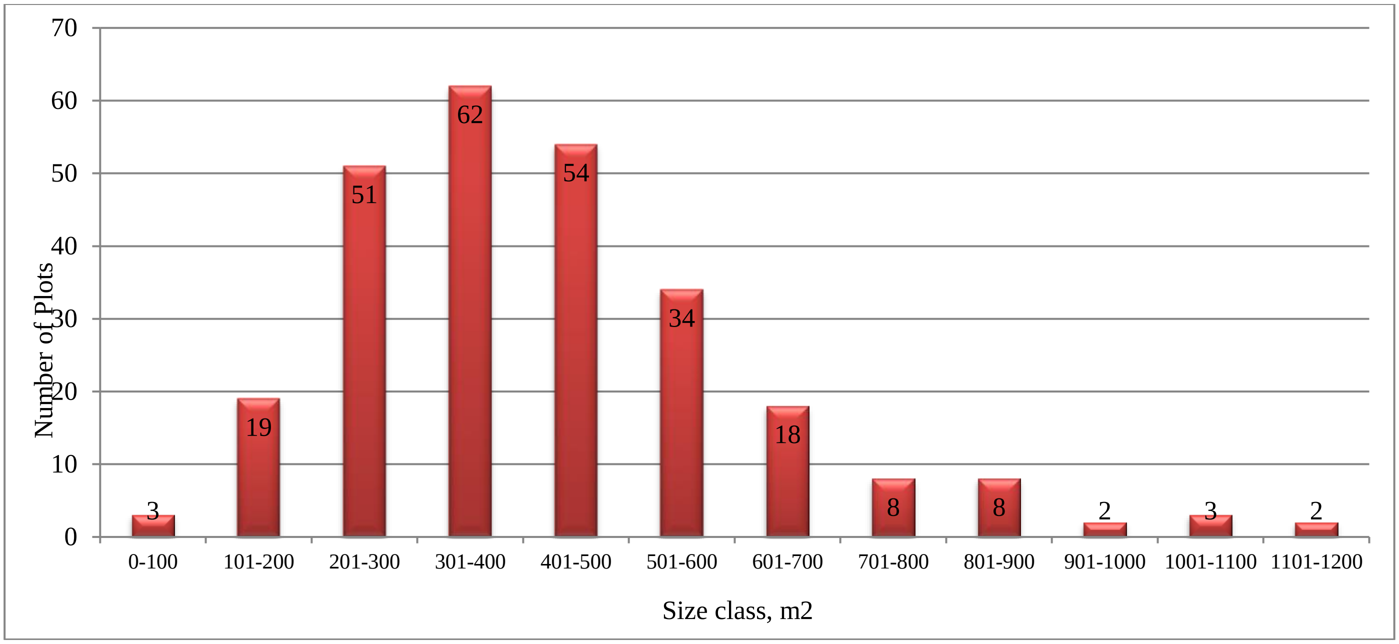


Figure-4: Distribution of size classes of different plots measured for fuel consumption study.

Table-2: The basic statistical analyses of the plot areas.

Mean	459.50
Standard Error	16.26
Median	402.77
Mode	289.58
Standard Deviation	267.19
Sample Variance	71393.13
Kurtosis	9.86
Skewness	2.52
Range	2086.65
Minimum	75.44
Maximum	2162.09
Sum	124064.94
Count	270.00

From the above statistical data it shows that the minimum plot area measured was 75.44 m^2 and the maximum was 2162.09 m^2. Between this sizes range, the plots were grouped into 12 classes by taking 100 m^2 intervals for easy assessment.

From the above figure, it shows that 261 plots among 270 fall in the range between 101 m^2 and 1200 m^2. This represents almost 97% of the total plots studied. However, the maximum plots fall between 101 to 700 m^2 which are totally 238 numbers that represents 88% of the total plots. Therefore, it will be justifiable if we consider plots within this range for further e.g., fuel consumption study. Another consideration is the shape of land selected for tillage operations and fuel consumption study, because shape of plots also affects the turning losses of power units and thus affects fuel consumptions. Figure-5 shows the frequency of different shapes of land area measured in the study.

From Figure-5, it shows that majority of the plots fall in the shapes of rectangular, trapezoidal, pentagon and hexagonal and represents almost 90% of the total shapes. Therefore, these four shapes will be considered in case of tillage operations for fuel consumption study. From the above analysis, it is evident that four shapes of land between the size category of 101 m^2 and 700 m^2 will represent maximum land sizes in the study area for fuel consumption study in tillage operations. The size ranges of measured plots for different villages are shown in the Table-3.

Tillage Operations: The tillage operations for several plots within above area range were performed using tractors and power tillers. For the fuel consumption test, the area of the desired plot was measured by measuring the length and width. At the beginning of the test, the fuel tank of the power tiller or tractor was filled with fuel (diesel). Then the tillage operation performed at suitable setting of the gear. After the tillage operation, the fuel tank refilled with diesel fuel and the amount required to fill the tank was recorded this was the actual amount of fuel consumption for the operation. The results of tilling several plots are shown in Table-4.

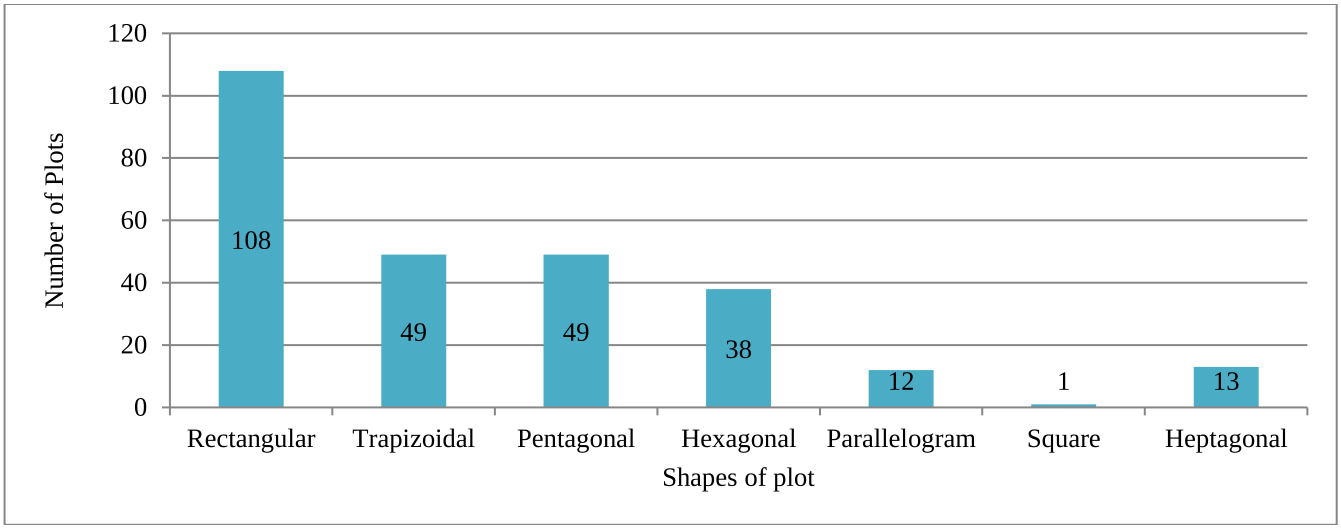


Figure-5: Distribution of different shapes of land measured for fuel consumption study.

Table-3: Distribution of different plot sizes in the maximum size ranges in 18 villages under the present study.

Villages	No. of plots in the size (M2) Ranges												Total
	0-100	101-200	201-300	301-400	401-500	501-600	601-700	701-800	801-900	901-1000	1001-1100	1101-1200	
Ghoraban	1	1	6	2	1	1	2	1	0				15
Uttarpalta	0	0	1	4	4	0	2	3	0	1	0	0	15
Kajal	0	2	9	4	0	0	0	0	0	0	0	0	15
Kobirajhat	1	2	4	2	3	1	2	0	0	0	0	0	15
Krishnapur	0	1	3	5	2	1	1	0	0	0	0	1	14
Chaolia	0	0	3	1	10	0	1	0	0	0	0	0	15
Chakpatla	0	0	0	5	1	3	2	0	1	0	0	1	13
Chow pukuria	0	0	0	3	4	5	0	0	1	0	0	0	13
Prannagar	0	1	3	5	2	3	1	0	0	0	0	0	15
Prembazar	1	5	2	3	4	0	0	0	0	0	0	0	15
Kolyani	0	3	1	6	1	2	0	0	0	0	2	0	15
Doriapur	0	1	2	5	2	2	0	0	2	0	1	0	15
Nandiagaon	0	1	5	3	2	1	1	0	2	0	0	0	15
Madati	0	0	4	5	2	4	0	0	0	0	0	0	15
Brahmanvita	0	0	1	2	6	1	3	0	0	1	0	0	14
Hatkali bazar	0	1	0	1	3	5	2	3	0	0	0	0	15
Golapgonj	0	0	4	1	4	3	0	1	2	0	0	0	15
Mohadevpur	0	1	3	5	3	2	1	0	0	0	0	0	15
Total	3	19	51	62	54	34	18	8	8	2	3	2	264

Table-4: Results of time and fuel consumption study by power tiller for clay.

Plot no. and Shape	Tilling condition	Avg. length of the plot, m	Avg. width of the plot, m	Area of the plot, m^2	Time required, min	Time required, hr/ha	Fuel consumption, ml	Fuel consumption, lit/ ha
1 Trapezoidal	1st	54.70	11.74	642.18	13	3.37		
	2nd	54.70	11.74	642.18	12	3.11		
2 Pentagonal	1st	28.87	29.30	845.89	17	3.35		
	2nd	28.87	29.30	845.89	18	3.55		
3 Triangular	1st	18.10	8.86	160.37	5	5.20		
	2nd	18.10	8.86	160.37	4	4.16		
	3rd	18.10	8.86	160.37	3	3.12		
4 Triangular	1st	13.90	8.43	117.18	3	4.27		
	2nd	13.90	8.43	117.18	2	2.84		
5 Hexagonal	1st	33.32	14.78	492.47	12	4.06	440	8.93
	2nd	33.32	14.78	492.47	10	3.38	410	8.33
6 Regtangular	1st	29.57	16.06	474.89	9	3.16	380	8.00
	2nd	29.57	29.06	474.89	8	2.81	350	7.37
7 pentagonal	1st	29.47	14.28	420.83	8	3.17	350	8.32
	2nd	29.47	14.28	420.83	10	3.96	400	9.51
8 Regtangular	1st	30.67	16.67	511.27	9	2.93	360	7.04
	2nd	30.67	16.67	511.27	8	2.61	320	6.26

Table-5: Results of time and fuel consumption study by Tractor.

Type of land	Plot No.	Tilling Condition	Avg. length of the plot, m	Avg. width of the plot, m	Area of the plot, m^2	Time required, min	Time required, hr/ha
Clay	1.00	1st	55.96	16.42	918.86	14	2.54
	2.00	1st	38.05	38.97	1482.81	30	3.37
	3.00	1st	17.57	17.47	306.95	5	2.71

The plots sizes were selected randomly as available in the field. Similar experiments were done for tractor and the results are shown in Table -5.

Results of the above tillage operations using tractor and power tiller is not enough to draw general conclusions about different plot sizes and of different shapes. It needs total study of different shapes of plots within the maximum frequency size ranges as shown in Table-3. However from the above study it can be seen that, time and fuel requirement reduces for the second time tillage than the first time and also when used higher gear than lower ones. Soil condition is another important factor which must be taken in to considerations. When the land is tilled for the first time, the soil is compact and takes more energy to open the land. From Table-4, it shows that the fuel consumption was less in 2^{nd} or 3^{rd} tillage than the first ones. Once we have the whole study of the plot sizes in the maximum size range and covering the maximum shapes, and include the soil moisture conditions, a complete suggestion could be made for efficient fuel consumption in tillage operations.

Conclusion

This study was conducted in Birganj Upazilla of Dinajpur District for assessing land use pattern and fuel use economy in tillage operations. Total 270 plots from 18 different villages were studied 15 plots from each village. From the studied areas, it was found that plot sizes varied from 75.44 m^2 to 2162.09 m^2. However the most frequent sizes were found between 101 m^2 and 700 m^2 coverings almost 88% when grouped into size classes at 100 m^2 interval. Also different shapes of plots were found from the study such as rectangular, trapezoidal, pentagonal, hexagonal, octagonal, square, parallelogram etc., however, rectangular, trapezoidal, pentagon and hexagonal shapes covered almost 90% of the plot area measured. It could be decided therefore that these shapes and size classes will be most suitable for studying fuel consumption experiments using tractors and power tillers.

Tillage operations were performed using tractors and power tillers within the size range mentioned above. In almost all cases, first time tillage was found to consume more time and fuel than the subsequent operations by tractors and power tillers. Again lengthwise tilling operations consumed less fuel than widthwise due to less turning losses. A clearer picture of the most efficient tillage operations could be obtained when tillage operations could be performed covering these whole size classes and using the most frequent land shapes.

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