*International Journal of Agricultural Engineering,* Vol. 3 No. 2 (October, 2010) : 209 -213

*Research Paper :*

# Variable cost analysis of different agricultural tractors

**HITESH SANCHAVAT,** R.B. VERMA AND V.V. AWARE

**Accepted :** *May, 2010*

See end of the article for authors' affiliations

Correspondence to:
**HITESH SANCHAVAT**
Department of Renewable Energy Source, Maharana Pratap University of Agriculture and Technology, UDAIPUR (RAJASTHAN) INDIA

## ABSTRACT

A study was conducted on the effect of power range and make of tractor on the maintenance, repair and fuel consumption of different make and power range of tractors. Tractors were classified into three power ranges *i.e.* 16-26 kW, 26-36 kW and 36-46 kW and in each power range four makes ($M_1$, $M_2$, $M_3$ and $M_4$) were selected for study. These tractors were mainly engaged for seed bed preparation and sowing. The basic data for maintenance and repair cost of tractors were collected from the University Farms, Crop Research Centre, Instructional Dairy Farm and the farms in the near by area of Govind Ballabh Pant University of Agricultural and Technology, Pantnagar, India. Field experiment was conducted to evaluate fuel and specific fuel consumption of various make and power range of tractors at Crop Research Centre, Pantnagar, during the year 2006-2007. Based on the variable cost and specific fuel consumption it was concluded that $M_1$ make tractors had least expenditure on repair and fuel cost during initial 4000 hours use.

**Key words :** Variable cost, Fuel-consomption, Specific fuel consumption

Agricultural mechanization implies the use of various power sources and improved farm tools and equipment, with a view to reduce drudgery of the human being and draught animals, enhance cropping intensity, precision, timeliness of operations, efficient utilization of crop inputs and to reduce losses at different stages of crop production. The end objective of farm mechanization is to enhance the overall productivity with increased economic returns. The agricultural tractor represents the central component of any mechanized farming system. The average power availability in India is 1.15 kW/ha where as the world average is more than 3.5 kW/ha and it needs to be increased to at least 2 kW/ha (Pandey and Mehta, 2007). Indian tractor industry is now the largest in the world with an average production of more than 2.5 lakes unit per year. However, in terms of total tractors used, the country ranks 8th in the world.

The country has tractor density of 10.5 tractors per thousand hectares of gross cropped area (GCA) compared to the international average of about 28 tractors per thousand hectares GCA (Pandey and Tewari, 2004).

Agricultural tractor production in India started in the year 1961. M/s Eicher Good Earth Ltd. is the first tractor manufacturer in India. The advent Green revolution in the late sixties helped manifold rise in the use of tractors on Indian farms. Presently, there are fourteen manufacturers of tractors producing various models in different power range. The current population of tractors is near the three million and every year about 2, 50,000 are being added to the fleet (Singh, 2006). The effectiveness of the agricultural resources can be increased by using improved machinery and tractor efficiently.

Fuel consumption of tractor is major constituent of variable (operating) cost. Diesel fuel prices have been rising significantly over the past few years. In many areas, prices have risen by 40% or more which means higher operating cost for farm tractors. Improving fuel efficiency of tractor engines is a matter of national importance. Any saving in fuel consumption would reduce the drain of foreign exchange and therefore should receive utmost priority from all concerned. Reducing the specific fuel consumption by selecting appropriate make and model of tractor requires a specialized expertise and knowledge. To keep the tractor in working condition periodic maintenance and repairs are essential. Periodic maintenance is systematic series of inspections and operations performed periodically to maintain or improve the efficiency and performance of the tractor. Timely repair will also reduce the occurrence of breakdown and repair cost. Repair, maintenance and fuel consumption of different make and power range of tractors may not be similar and these may have significant effects on the variable (operating) cost.

## METHODOLOGY

Selection of tractors was based on PTO power and make of the tractor. The data for maintenance and repair cost analysis of tractors were collected from the University Farms, Crop Research Centre, Instructional

Dairy Farm and the farms in the near by area of Govind Ballabh Pant University of Agricultural and Technology, Pantnagar. These data have been recorded from the log books of tractors, store indent books.

**Table 1 : Details of tractors selected for study**

| Sr. No. | Tractor PTO Power Range, kW | Make | PTO Power, kW |
|---|---|---|---|
| 1. | 16-26 ($P_1$) | $M_1$ | 24.4 |
| | | $M_2$ | 25.5 |
| | | $M_3$ | 24.8 |
| | | $M_4$ | 20.9 |
| 2. | 26-36 ($P_2$) | $M_1$ | 32.5 |
| | | $M_2$ | 31.8 |
| | | $M_3$ | 30.1 |
| | | $M_4$ | 33 |
| 3. | 36-46 ($P_3$) | $M_1$ | 37.4 |
| | | $M_2$ | 37.8 |
| | | $M_3$ | 39.8 |
| | | $M_4$ | 38.9 |

$M_1$ : John Deere, $M_2$ : Mahindra, $M_3$ : Sawaraj/Farm track
$M_4$ : HMT/Massey-Ferguson

Field experiment was conducted to evaluate fuel consumption of various make and power range of tractors by pulling a harrow in uniform field conditions at Crop Research Centre during the year 2006-2007. Necessary modifications in the fuel supply system of each tractor were made for the measurement of fuel consumption (Fig.1 and 2). The fuel measuring device consisting of an auxiliary tank, main fuel tank and control valves was fabricated. A trailed type two gang, 16 discs offset disc harrow was used to put the draw bar load on the tractors in the field during the test. A hydraulic drawbar dynamometer having 2000 kg safe working load capacity was used for measuring the drawbar load. Experiment was laid down in Completely Randomized Design with three replications. Experiment was conducted with in 13-15% travel reduction and speed range of 3 to 7 km/h of tractor. Gear position for getting desired slip and speed was determined by putting drawbar load on tractor and using trial and error method. Data regarding wheel slippage, time of travel, drawbar load and fuel consumption were recorded for 50 meter test distances.

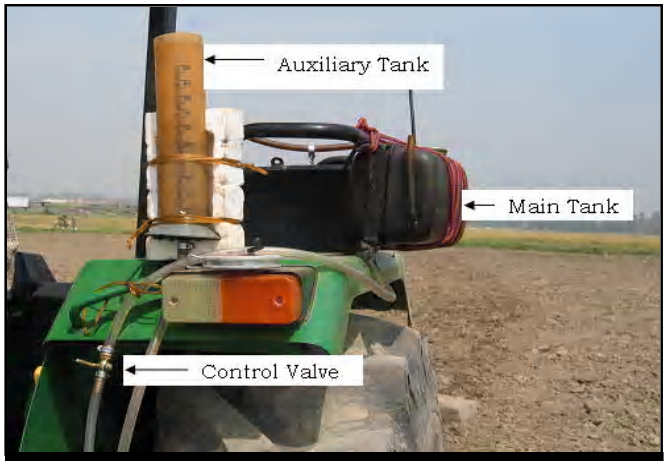


**Fig. 1: Arrangement for measurement of fuel consumption**

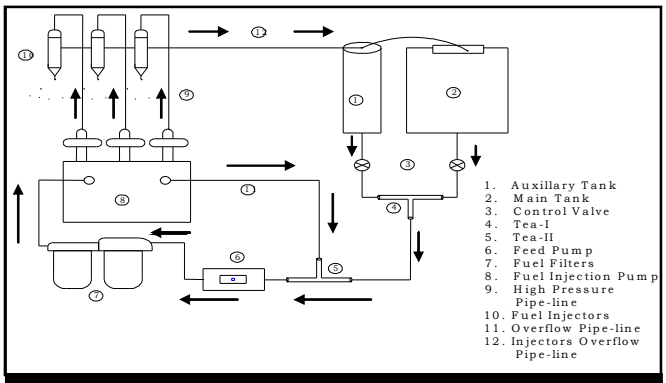


**Fig. 2 : Schematic diagram of fuel supply system**

## RESULTS AND DISCUSSION

The results obtained from the present investigation are summarized below :

### Maintenance schedule and cost:

Maintenance involves periodic activities to prevent premature failure and to maintain good functional performance. Periods of maintenance schedule were taken such that at least each item needed for maintenance of tractor is changed once. Maintenance cycles for different make of tractors were different. Engine oil, PY0025 was required for $M_1$ make tractors and cost Rs 140 per l while the engine oil, Servo 20W40 was required for other make of tractors ($M_2$, $M_3$ and $M_4$) and cost Rs 106 per l only. Transmission oil, PY0023 was required for $M_1$ make tractors and cost was Rs 122 per litre while the transmission oil, HP90 was required for other makes of tractor and cost was Rs 101 per l only. Based on the maintenance cycles given in the operator manuals of different tractors hourly maintenance costs had calculated. The maintenance costs per hour tractors in 16-26 kW were Rs 11.59, 9.26, 10.59 and 11.36, respectively, for $M_1$, $M_2$, $M_3$ and $M_4$ make. The maintenance costs in term of rupees per hour for $M_1$, $M_2$, $M_3$ and $M_4$ tractors in 26-36 kW were Rs. 11.87, 9.62, 10.99 and 12.10, respectively. The total maintenance costs per hour for these tractors in 36-46 kW were Rs 12.36, 10.01, 12.20 and 14.46, respectively.

**Repair cost of tractors:**

Repair cost involved minor repair to maintain operative condition of tractor. It includes replacement of electrical component, bearing, hub seal, nut bolt, fan belt and fuel pipe etc. Data of repair cost for initial 4000 hours were collected for all power range and make of tractors. Repair costs of $M_1$, $M_2$, $M_3$ and $M_4$ tractors in 16-26 kW power range were Rs 1988, 2745, 3041.67 and 2953, respectively. Repair costs of $M_1$, $M_2$, $M_3$ and $M_4$ tractors in 26-36 kW power range tractors were Rs 3018, 4333, 3881 and 4818, respectively. Repair costs of these make tractors in 36-46 kW power range were Rs 4400, 5606, 6014 and 8052, respectively. The statistical analysis was conducted using two factors Completely Randomized Design to observe the effect of power range and make of tractors on repair cost. The power range and make of tractors have significant effect on tractor repair cost at 1% level of significance. The second order interaction of these parameters had also significant effect on repair cost at 5% level of significance. This is in agreement with the finding of Saini and Khan (2006). Repair cost was minimum for $P_1M_1$ and maximum for $P_3M_4$ tractor.

**Fuel consumption:**

The experiments were conducted to evaluate fuel consumption of various make and power range of tractors by pulling a harrow in uniform field conditions. The average initial bulk density and moisture content were 1.58 g/cc and 10.93 % (db), respectively. Fuel consumption of $M_1$, $M_2$, $M_3$ and $M_4$ tractors in 16-26 kW power range was 2.97, 3.14, 3.58 and 3.03 l/h, respectively. Fuel consumption of these tractors in 26-36 kW power range was 4.02, 4.22, 4.78 and 4.90 l/h, respectively. Fuel consumption of these tractors in 36-46 kW power range was 5.52, 5.88, 6.12 and 7.65 l/h, respectively. The statistical analysis was conducted using two factors Completely Randomized Design to observe the effect of power range and make of tractors on fuel consumption. The power range and make of tractors have significant effect on tractor fuel consumption at 1% level of significance. The second order interaction of these parameters had also significant effect on fuel cost at 1% level of significance.

**Variable cost:**

Variable cost includes maintenance cost, repair cost and fuel cost of the tractors. Variable costs of $M_1$, $M_2$, $M_3$ and $M_4$ tractors in 16-26 kW power range were Rs. 110.73, 114.46, 130.39 and 112.96 per hour, respectively. Variable costs of these tractors in 26-36 kW power range were Rs. 146.29, 151, 170.89 and 176.89, respectively. Variable costs of $M_1$, $M_2$, $M_3$ and $M_4$ tractors in 36-46 kW power range were Rs 197.22, 206.92, 217.19 and 270.72 per hour, respectively.

Result of ANOVA reveals that power range and make of tractors have significant effect on tractor variable


**Fig. 3: Variation in variable cost with the make of tractors for different power range**

**Table 2 : ANOVA for variable cost of tractors**

| | | | | | | |
|---|---|---|---|---|---|---|
| 1st factor means | 117.13 | 161.10 | 223.01 | | | |
| 2nd factor means | 151.41 | 157.46 | 172.82 | 186.64 | | |
| Source | D.F. | S.S. | M.S.S. | Fcal. | S.E.M. | C.D. |
| P | 2 | 67903.73 | 33951.86 | 6683.62** | .65 | 2.57 |
| M | 3 | 6780.34 | 2260.11 | 444.91** | .75 | 2.97 |
| Interaction of PM | 6 | 5585.82 | 930.97 | 183.26** | 1.30 | 5.14 |
| Error | 24 | 121.91 | 5.07 | | | |
| Total | 35 | 80391.81 | | | | |
| CV=1.35 | | | | | | |

** indicates significance of value at P=0.01

**Table 3 : Specific fuel consumption of tractors**

| Sr. No. | Tractor | Draft, kN | Speed, km/h | Fuel consumption, l/h | Specific fuel consumption, g/db-kW-h |
|---|---|---|---|---|---|
| 1. | $P_1M_1$ | 5.82 | 4.51 | 2.97 | 335 |
| 2. | $P_1M_2$ | 5.76 | 4.48 | 3.14 | 361 |
| 3. | $P_1M_3$ | 5.82 | 4.49 | 3.58 | 407 |
| 4. | $P_1M_4$ | 5.89 | 4.41 | 3.03 | 346 |
| 5. | $P_2M_1$ | 6.93 | 4.94 | 4.02 | 348 |
| 6. | $P_2M_2$ | 7.00 | 4.90 | 4.22 | 365 |
| 7. | $P_2M_3$ | 7.00 | 4.93 | 4.78 | 411 |
| 8. | $P_2M_4$ | 7.00 | 5.03 | 4.90 | 412 |
| 9. | $P_3M_1$ | 8.89 | 5.27 | 5.52 | 349 |
| 10. | $P_3M_2$ | 8.89 | 5.28 | 5.88 | 371 |
| 11. | $P_3M_3$ | 8.76 | 5.04 | 6.12 | 411 |
| 12. | $P_4M_4$ | 8.96 | 5.93 | 7.65 | 426 |

cost at 1% level of significance. The second order interaction of these parameters has also significant effect on variable cost at 1% level of significance. It was found that as power range increases variable cost also increases as shown in Fig.3. The similar results were reported by Shambhu and Choudhary (2007). They reported that tractor operational cost per hour increased with the increase in the size of tractor.

**Specific fuel consumption of tractors:**

Specific fuel consumption was calculated from the observation of fuel consumption and drawbar power and it is presented in Table 3.

Specific fuel consumption of $M_1$, $M_2$, $M_3$ and $M_4$ make of tractors in 16-26 kW was 335, 361, 407 and 346 g/db-kW-h, respectively. The specific fuel consumption of $M_2$, $M_3$ and $M_4$ make of tractors as compared to $M_1$ make of tractor was 8, 21 and 3 per cent higher, respectively. In this power range specific fuel consumption was minimum for $M_1$ and maximum for $M_3$ make of tractor. Specific fuel consumption of $M_1$, $M_2$, $M_3$ and $M_4$ make of tractors in 26-36 kW was 348, 365, 411 and 412 g/db-kW-h, respectively. The specific fuel consumption of $M_2$, $M_3$ and $M_4$ make of tractors was 5, 18 and 18 per cent higher, respectively as compared to $M_1$ tractor. In this power range specific fuel consumption was minimum for $M_1$ and maximum for $M_4$ make of tractor. Specific fuel consumption of $M_1$, $M_2$, $M_3$ and $M_4$ make of tractors in 36-46 kW was 349, 371, 411 and 426 g/db-kW-h, respectively. The specific fuel consumption of $M_2$, $M_3$ and $M_4$ make of tractors as compared to $M_1$ make was 6, 18 and 22 per cent higher, respectively. In this power range specific fuel consumption was minimum for $M_1$ and maximum for $M_4$ make of tractor.

**Conclusion:**

The data were analyzed and based upon experimental results following conclusions were drawn.

– In all power ranges, maintenance cost was minimum for $M_2$ make tractors. It was maximum for $M_1$ make tractors in 16-26 kW power range and $M_4$ make tractors had maximum maintenance cost in the power ranges of 26-36 and 36-46 kW.

– It was found that $M_1$ make tractors had minimum

repair cost in all power ranges. Repair cost was maximum for $M_3$ make tractors in 16-26 kW power range and for $M_4$ make tractors in 26-36 and 36-46 kW power ranges.

– Fuel consumption was minimum for $M_1$ make tractors in all power ranges. In 16-26 kW power range fuel consumption was maximum for $M_3$ make tractors and it was maximum for $M_4$ make tractors in 26-36 and 36-46 kW power ranges.

– In all power ranges, variable cost was minimum for $M_1$ make tractors. It was maximum for $M_3$ make tractors in 16-26 kW power range and maximum for $M_4$ make tractors in 26-36 and 36-46 kW power ranges.

– It was found that $M_1$ make tractors had minimum specific fuel consumption in all power ranges. $M_3$ make tractor gave maximum specific fuel consumption in 16-26 kW power range and $M_4$ make tractors in 26-36 and 36-46 kW power ranges.

– Variable cost and specific fuel consumption increases with the power of tractor.

Based on variable cost and specific fuel consumption $M_1$ make tractors have least expenditure in the operation as compared to other makes of tractor for 1st 4000 hrs of work.

Authors' affiliations:
**R.B. VERMA,** Department of Farm Machinery and Power Engineering, G.B. Pant University of Agriculture and Technology, Pantnagar, U.S. NAGAR (UTTARAKHAND) INDIA
**V.V. AWARE,** Department of Farm Machinery and Power Engineering, Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli, RATNAGIRI (M.S.) INDIA

## REFERENCES

**Pandey, M. and Tewari, M. (2004).** Management Case Study: Indian Tractor Industry. *Rural & agirc. Mrkg.*, **22** : 332-354.

**Pandey, M. M. and Mehta, C. R. (2007).** Agricultural Engineering for enhancing productivity and employment- role of agricultural mechanization. Paper presented in 41st Annual Convention of ISAE held on January 29-31.

**Saini, A.K. and Khan, A. (2006).** A study on fuel consumption of tractors of University Farm. B.Tech Thesis, G. B. Pant University of Agriculture and Technology, Pantnagar (Uttarakhand).

**Shambhu, V. B. and Choudhary, S. K. (2007).** Tractor utilization pattern in Nalanda district of Bihar by farmers-A case study. Paper presented in 41st Annual Convention of ISAE held on January 29-31.

**Singh, G. (2006).** Agricultural Machinery Industry in India (Manufacturing, marketing and mechanization promotion). Status of Farm Mechanization in India. pp. 154-174.

***