ISSN No. 2395-0900
International Journal of
Engineering Studies and Technical Approach

Staggered Reciprocating Sub-Soiler Shanks and Tractor Forward Speed and Their Influence on Power Requirement and Soil Profile

Abdalla.N. O. Kheiry*, & Zhang dong xing**

Department of Agricultural Engineering College of Agricultural Studies Sudan University of science and Technology Khartoum Suda.
*****College of Engineering- China Agricultural University Beijing china.***

ABSTRACT:

The new sustainable of tillage system needs new machines which are the combination of well accepted disc harrow and cultivator or chisel/ripper. A staggered reciprocating vibrating subsoiler that, was developed by Agricultural Mechanization Engineering, Department - China Agricultural University to overcome the soil compaction problems which is common in corn fields due to use of heavy agricultural equipment, tractors and the continuous plowing of agricultural soil at the same depth. Field experiments were conducted to determine the influence of subsoiler shanks working mode under different forward speeds on the power requirements and soil cross section area (soil profile). Field tests were conducted at the Demonstration Farm of the Guan Jingquan Jixie tanhuang Factory - Gu An city in He bei province, China in 2013.

Total power required for vibrating shank (VS) was 8.94, 10.85 and 10.12 kW at forward speeds of sp1, sp2 and sp3 respectively. It was slightly greater than the power required for non- vibrating shank (NVS) by about 8.05%, 2.3% and 8.4% at the same forward speeds respectively. The mean cross section area was observed significant difference ($P<0.05$) between two shank working style, while among the three different forward speeds had no significant, also the results showed that, with increased in speed from speed one to speed three resulted to decrease the soil cross section area in both mode of shank working.

Keywords: *PTO power, soil profile, vibration machine,*

INTRODUCTION

There are many factors that control the performance of subsoilers. These factors can be divided into three sections: soil, plow and operation. Soil variables include: soil moisture content (M.C.), organic matter, soil bulk density and structure. Plow variables include: Plow weight, shape and number of shanks and blades. Operation variables include: forward speed, width and ploughing depth.

The use of vibrating or oscillating subsoiler is one technique that can reduce the draft force when the maximum velocity of oscillation is greater than the velocity of the tool carrier (Yow and Smith, 1976). The reduction of draft was the most important performance indicator of subsoilers (Sakai et al., 1988).

There are several researchers have studied various parameters to minimize the draft force and total power. Bandalan et al. (1999) studied vibrating subsoilers and found that draft ratio decreased rapidly when the velocity ratio increased to 2.25. The draft ratio decreased slowly, however, when the velocity ratio was grater than 2.25.

Over many years, a lot of research has been conducted on aspects of draft reduction and efficient soil loosening of oscillatory tillage. All researchers showed that oscillating or vibrating tillage tools can considerably decrease draft; however there are often discrepancies on the effect of oscillation. (Slattery and Desbiolles 2002). Past research also revealed that amplitude, frequency and tractor velocity are very important parameters affecting the performance of oscillatory tillage. The above three parameters are usually combined into a velocity ratio term, describe by Shahgoli et al (2007). However, there are few studies comparing the power requirement and soil cross-section area of different types of vibration implement.

The objectives of the present study was to compare between two shank working modes of a staggered reciprocating subsoiler under different forward speeds and their influence on the total power requirements and soil cross section area (soil profile).

MATERIALS AND METHODS

Experimental Site

The study was carried out at Farm of the Guan Jingquan Jixie tanhuang Factory - Gu An city in He bei province (116°17′E, 39°19′N) southern of Beijing, where it has a flat terrain with ratio of slope is below 5° and 500-600 mm average rainfall. The experiments were conducted at 2013. Soil texture was found to be silt clay soil (Li xia and Zhang dong 2011).

Experimental Design and Treatment Applications

The layout of the experiment was a split-plot design, with a factorial arrangement of treatments consisting of two shanks working modes (VS) and (NVS) as main plot and three tractor forward speeds (Sp1, Sp2 and Sp3) as sub-plot with three replications giving a total of eighteen plots.

The treatments were randomly distributed in the main and sub-plots. Sub-plot area was 108 m^2 (30 m x 3.6 m) were separated by a distance of 1.0 m and by distance 5.0 m at the end of sub-plot. A mounted staggered reciprocating subsoiler (Fig. 1) which was developed by China Agricultural University was used for all the tests. The shanks of this implement can operate under two different situations:

1 – VS is Vibrating status it was obtained through operated the implement with the tractor power-take-off (PTO)

2 – NVS is Non vibrating status this situation could be obtained by turn off the PTO of the tractor. The implement had four vibrated shanks arranged as a semi V shape in two rows with distance 60cm between shanks.

Two tractors were used in this experiment, one for testing and the other as auxiliary for pulling. The soil bulk density, soil moisture content and soil penetration resistance of the 0-10, 10-20 and 20-30cm of the experimental site are shown in Table 1. The experimental site was cropped with corn (zea maize) in previous year. For all treatments the engines speed of the tractor adjusted by using a fuel hand accelerator lever to maintain steady engine rpm on the dashboard. The tillage depth was adjusted to 30 cm.

Table 1: Some soil properties of the experimental site before test:

Depth (cm)	Bulk density (gm/cm3)	Moisture content (%)
0 – 10	1.57	9.21
10 – 20	1.63	9.19
20 – 30	1.68	12.1

Fig. 1 Photographic view of new developed chisel plow.

Measurements

Drawbar and PTO power requirement

The drawbar power exerted by the tractor to pull the implement was calculated as follows:

$$Dbpr = (f \times sp)/3.6 \quad \ldots\ldots\ldots\ldots\ldots\ldots.. \quad (3.3)$$

Where:

$Dbpr$ = drawbar power (kW), f = implement draft (kN), sp = Travel speed (km/h).

The torque and the rotation of the PTO were measured simultaneously. PTO torque was measured by a torsiometer had a capacity of 1000 N m, that was located between the tractor PTO and the implement PTO input Figure (2) and connected to a data acquisition system constituted of the data logger Figure (3) which was connected to the parallel port of a portable computer.

The data were obtained using the software NJDLXCSYCE Chinese version in Windows environment. The PTO power exerted by the tractor to operate the implement was calculated as follows:

$$PTOpr = \frac{t \times rpm}{9550}$$

Where:

PTO pr = *PTO* power (kW), *t* = torque (n.m), *rpm* = PTO rotation or revaluation per minute and 9550 = conversion factor.

$$T.pr = dbpr + PTOpr$$

Where:

T.pr = power requirement when the implement in vibrating working style.

ISSN No. 2395-0900

Fig. 2 Photographic view of PTO torque torsiometer located between the tractor and the implement with a detailed view on the up-left photographic

Fig. Error! No text of specified style in document. Photographic view of data logger for data acquisition system

Soil profile (soil cross-section area):

To obtain the cross-sectional area of a plowing profile Profilometer device was used, each one of the two vertical ribs Profilometer device, dipped up to (5) cm in each furrow, then each of the metal rods, moved up or down till it only touch the surface of the furrow, then the displacement in each is calculated (Fig. 4). The cross-sectional area of the plow profile after movement of plowing machine was calculated using Simpson`s rule as follow:

$$S.P = \left[\frac{S}{3} \quad fc + lc \quad + 2 \ \sum sc \quad + 4 \ \sum dc \quad \right] \times 100$$

Where:
$S.P$ = soil profile (soil cross section area)
S = space between two rods.
Fc = first rod, lr = last rod, $\sum sr$ = sum of single rod and $\sum dr$ = sum of double rod

Fig. 4 Photographic view of Profilometer device used for measure soil profile

International Journal of
Engineering Studies and Technical Approach
ISSN No. 2395-0900

Effect of two shanks working mode and forward speed of a new design a staggered reciprocating motion chisel plow on the total power requirement:

The average power requirements as affected by the two working mode of a new developed vibratory chisel plow at experiment location are illustrated in Fig. 5. A statistically no significant difference ($P<0.05$) was observed in total power requirements between two shanks working mode (VS and NVS) for the three different forward speed (Sp1, Sp2 and Sp3) at experiment site Table (2).

Generally, it can be observed from this test that, the average power for (VS) working style has slightly greater than that of (NVS) working mode by 8.05% for speed 1, 2.3% for speed 2 and by 8.4% for speed3.

The average power requirement was recorded at three forward speeds viz., Sp1, Sp2 and Sp3, An increasing trend was observed in power requirement over speeds for all treatments (Fig. 5).

The interaction effect of the forward speed with shank working style shows was not significant ($P > 0.05$) at the expeirement site (Table 2).

The Duncan's multiple range test for power requirements showed no significant difference among the shanks working mode of a new developed chisel plow while there are a highly significant different was found among the three different forward speeds (Table 2). This test is used for ranking the means.

Table 2 Statistical description of variation for the Wheel slippage affected by tow shanks working style and different forward speed

source	S.S	M.S	Prob.	F. value
shanks	1.9273	1.92734	0.0760 ns	41.02*
Speed	17.0508	8.52542	0.0004**	4.98*
shanks×speed	0.3157	0.15787	0.6580ns	0.38 ns

S.S=Sum of squire, M.S = Mean of squire, Prob. =probability,* = significant and ns = no significant.

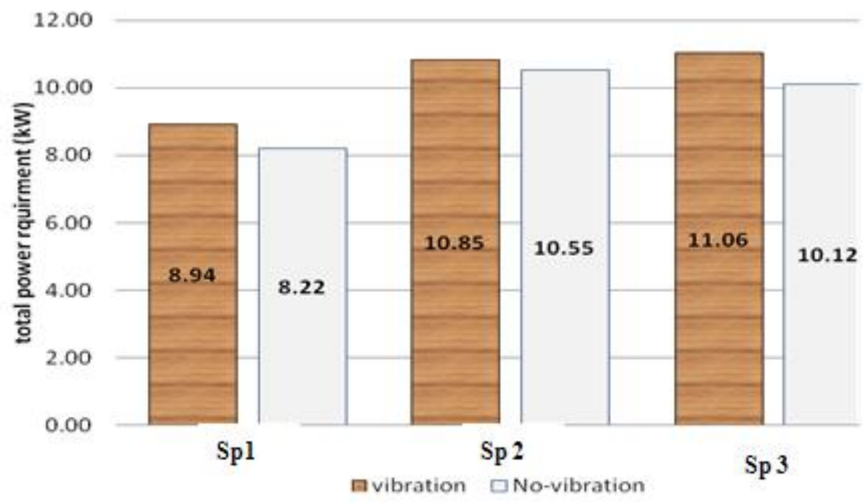

Fig. 5 Total power requirements for two shanks working mode under different working style (Mean followed by the different letter differ significantly according to Duncan's test $P < 0.05$).

ISSN No. 2395-0900
International Journal of
Engineering Studies and Technical Approach

Effect of two shanks working mode and forward speed of a new design a staggered reciprocating motion chisel plow on soil profile (cross section area):

The dominance of shanks working mode on soil cross section area or (soil profile) for the new developed vibrotary chisel plow is presentd in Fig. 6.
The ANOVA for the soil profile for two shanks working modes and different forward speed is shown in Table 3. Total cross section area had a highly significant difference (P<0.01) and was influenced significantly by the shanks working mode. On average, total soil profie was found greater in (VS) than (NVS). The results indicated that about 64.4% total area was more achived in (VS) than that of (NVS).

Table 3 ANOVA description for the soil cross section area at tow shanks working style and different forward speed

source	S.S	M.S	Prob	F
shanks	983971	983971	0.000**	38315
speed	4519	2260	0.1539 ns	2.39
shanks×speed	130	65	0.934 ns	0.07

S.S=Sum of squire, M.S = Mean of squire, Prob. =probability,** = significant and ns = no significant.

Soil profie was more achieved in VS of the new developed chiesel plow caused by increased in the top width of interrow tillage, in this study soil profile created by operating two shanks working style and various forward speed were worked out, and such results are presented in Figures 6, viewed from the front, the break-up around a chisel plough tine normally occurs in a semi V-shape (Figure 7 a and b) also it is clear that from the top width of the profile for the vibrating shank is wider than non-vibrating which it was arrange between 37 to 43 cm top width and 5cm bottom width and 30.5 to 33cm depth producing average cross section area 720cm^2 for the vibrating shank over all speeds, while productive top width, productive bottom width and ploughing depth in (NVS) were arranged as follows 20 to 25cm, 5 cm and 30.5 to 33cm respectivelly producing cross section area 436.56 cm^2 for all speeds. This may be due to with an increase in width of an interow tillage leads to an increase cross section, the increase in the cutting width were occurred as a result of vibration process, with vibrating shanks create more shake and break of soil clods at two sides of each shank resulted in more width for one shanks which is causes increase in total width and the cross sectionarea. Also found in literature is that the vibrations increase the soil brake up and amount of soil disturbed, these results are inline with results found by (Jaco., 2007).

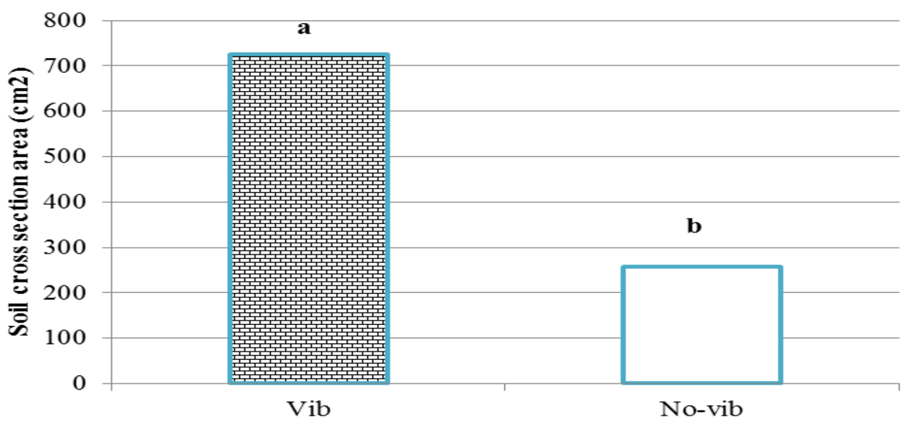

Fig. 6 The mean cross section area (cm3) for two shank working mode.

Fig. 7 (a) soil profile in vibrating shank. (b) Soil profile in no-vibrating shank.

Fig. 8 comprises the cross section area or soil profile was influenced by forward speed. Based on the cross section area parameter the results indicated that the soil profile or soil cross section area had no siginficant different btween speeds Table (3), while there are slight difference between three speeds were observed during the experiemnet which found that with increased in speed from speed one to speed three resulted to decrease the soil cross section area in both mode of shank working.

The interaction effect of average shanks working style and forward speeds on soil cross section area showed no siginficant ($P<0.05$), Table 3. The Duncan's multiple range test for cross section area was observed significant difference ($P<0.05$) among the two shank working style, while for the three different forward speeds had no signifcant at experiment site (Fig. 6 and Fig. 8).

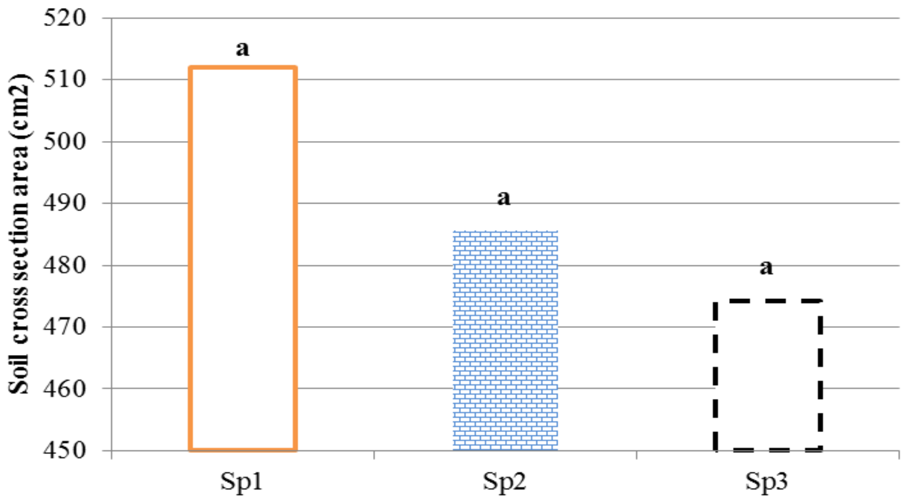

Fig. 8 The mean cross section area (cm^3) for three different forward speeds.

ACKNOWLEDGEMENTS

This work was supported by the National Maize Industry Technology R&D Center; Mechanized corn (CARS – 02), and

Production system optimization technology and equipment research demonstration projects (200903059).

REFERENCES

i. Bandalan, E. P., V. M. Salokhe, C. P. Gupta and T. Niyamapa. 1999. Performance of an oscillating subsoiler in breaking a hardpan. *Journal of Terramechanics* 36(2): 117- 125.

ii. Jaco van der Linde (2007). Discrete Elemente Modeling of aVibratory sybsoiler. Unpublished M. Sc. Thesis, department of Mechanical Engineering. University of Stellenbosh. South Africa.

iii. Lixia and Dongxing, 2011, The Research and Analysis of Anti-drag Mechanism for Vibratory Subsoiler. 978-1-4244-9577-1/11/$26.00 ©2011IEEE.

iv. Sakai, K., H. Terao and S. Nambu. 1988. The dynamic behaviour of a tractor-vibrating subsoiler system and the effect of the virtual hitch point. Journal of Terramechanics 25(4): 241-247.

v. Shahgoli, G., Saunders, C., Desbiolles, J., Fielke, J., 2007. Oscillation angle effects on the dynamic characteristics of vibratory tillage. Submitted to publish in the review book on Soil & Tillage Research.

vi. Slattery M and J Desbiolles (2002). Energy use and soil loosening performance of a vibratory subsoiler for soil amelioration in established vineyards. Paper 28 of the E-Proceedings of the 2002 Australian Conference on Engineering in Agriculture, 26-29 September 2002 Wagga Wagga - New South Wales, Australia.

vii. Yow, J. and J.L. Smith. 1976. Sinusoidal vibratory tillage. Journal of Terramechanics 13(4): 211 226.