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INFLUENCE OF SOIL CONDITIONS ON ABRASION WEAR BEHAVIOUR OF TILLAGE IMPLEMENTS

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Abstract- A major problem related to use of tillage equipments is abrasion wear by soil particles. Abrasive wear resistance of the materials depends upon the properties of soil and working conditions. Volume wear increases as the stone content of soil and its resistance to penetration by spherical probes increases. In soil, the abrasive type and the soil texture such as bulk density, water content and soil compactness etc affects the abrasive wear resistance of tillage tools. Soil moisture content also exerts a stronger effect upon wear than soil type characterized by its granular composition and an increase in the former decreases wear, with sandy soil. In present paper it is attempted to relate the influence of soil conditions on abrasive wear behaviour of tillage tools.
Keywords: Soil conditions, Abrasion wear, Soil moisture, Bulk density, Tillage implements.

1. INTRODUCTION

Abrasion by sand particles is an important factor that causes excessive wear of machine tools operating in soil. Ploughing by tillage tools such as cultivators, rotary tillers, moldboard plough, disc harrow and chisel plough etc. is the main primary cultivation operation in both dryland and irrigated farming system. Preparation of land with tillage tools provides more reliable and enables the farmers to achieve his target at right time. A major problem with agriculture tillage implements is the deterioration caused by soil hard particles. Wear caused by soil particles is abrasive in nature which affects the direct costs such as higher fuel consumption, lower rates of work and poor tillage quality. This rate of wear is influenced by various factors which may be divided into three categories, i.e., depends upon the soil condition (soil type, soil texture, bulk density and moisture content), operational factors (speed, depth of cultivation, tillage time) and implement design parameters. Other factors are pressure on tool and tool materials also influence the tool life [1].

Most of the ground gouging tools are usually made up of high carbon or low alloy steels [2]. Damaged tools are usually less efficient in terms of tillage or seeding efficiency, weed control and can cause more draft and fuel penalties [3]. The wear resistance of tillage tools is mainly associated with their surface hardness, higher material hardness will result in decrease in wear rate Basic requirements of a finished farming tool for normal soil are high hardness (38-45 HRC) and more abrasion resistance. However, higher hardness (50-60 HRC) is required in desert regions and in hard soil conditions [4]. The amount of steel mixed with soil, the human power, time losses due to the replacement of the worn parts of the tool and production losses affects the national economy badly [5].

Researchers have made efforts to find the effect of moisture content on abrasive wear behaviour of tillage tools [1,2,6]. Sadek et al., 2011 [7] studied the effect of moisture on shear behavior of a sandy soil. In this study researcher used three moisture levels and four bulk densities for tests. The results showed that the moist and wet soils had least shear forces, but the dry soil had higher yield forces.

Studies on wear of tillage tools subjected to the soil conditions and texture of soils were carried out by many researchers [8,910]. Scheffler and Allen, 1988 [11] reported that the abrasive wear rate of steels in South African soils were found to be twenty times greater in stony soil than in sandy soil and seven times more in clay soil.

2. FACTORS AFFECTING THE ABRASIVE WEAR

2.1 Soil type and texture

Type of soil and its texture is significant factor which affecting the abrasive wear rate of tillage implements. Diameter of particles greater than 0.01mm are characterized as sand (0.02-2.0mm), while the particle size less than 0.01mm are named clay (0.01-0.02mm) and when the size in between (0.002-0.02mm) called loam sand [10]. Woldman M. et al 2012 [12] studied the influence of sand properties on abrasive wear baehaviour of tools. Six types of sand was examined, one is commercially available as a reference in dry sand rubber wheel tester and other five were obtained from different geographical locations of the world (Afghanistan, Gambia I, Gambia beach II, Netherlands I, Netherlands beach II and Silver sand as a reference). The tests were performed on DIN St-52 steel to quantify the results obtained from these six sand particles. Fig. 1 shows the volumetric wear rate with respect to time for various sands, indicating that sand properties plays a

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significant role in abrasive wear behaviour. Netherlands II soil had less wear rate and reference sand showed more wear rate as compared to the other soils. Fig.2 shows the stereo-microscopic pictures of different sands used in research to give an idea about the shape and size of the particles.

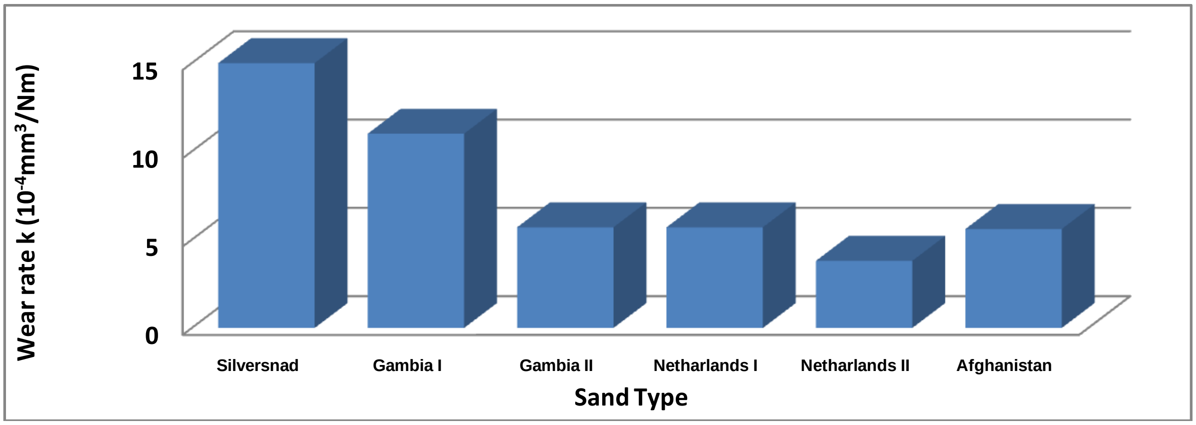

Fig.1 Wear rate of different types of sands [12].

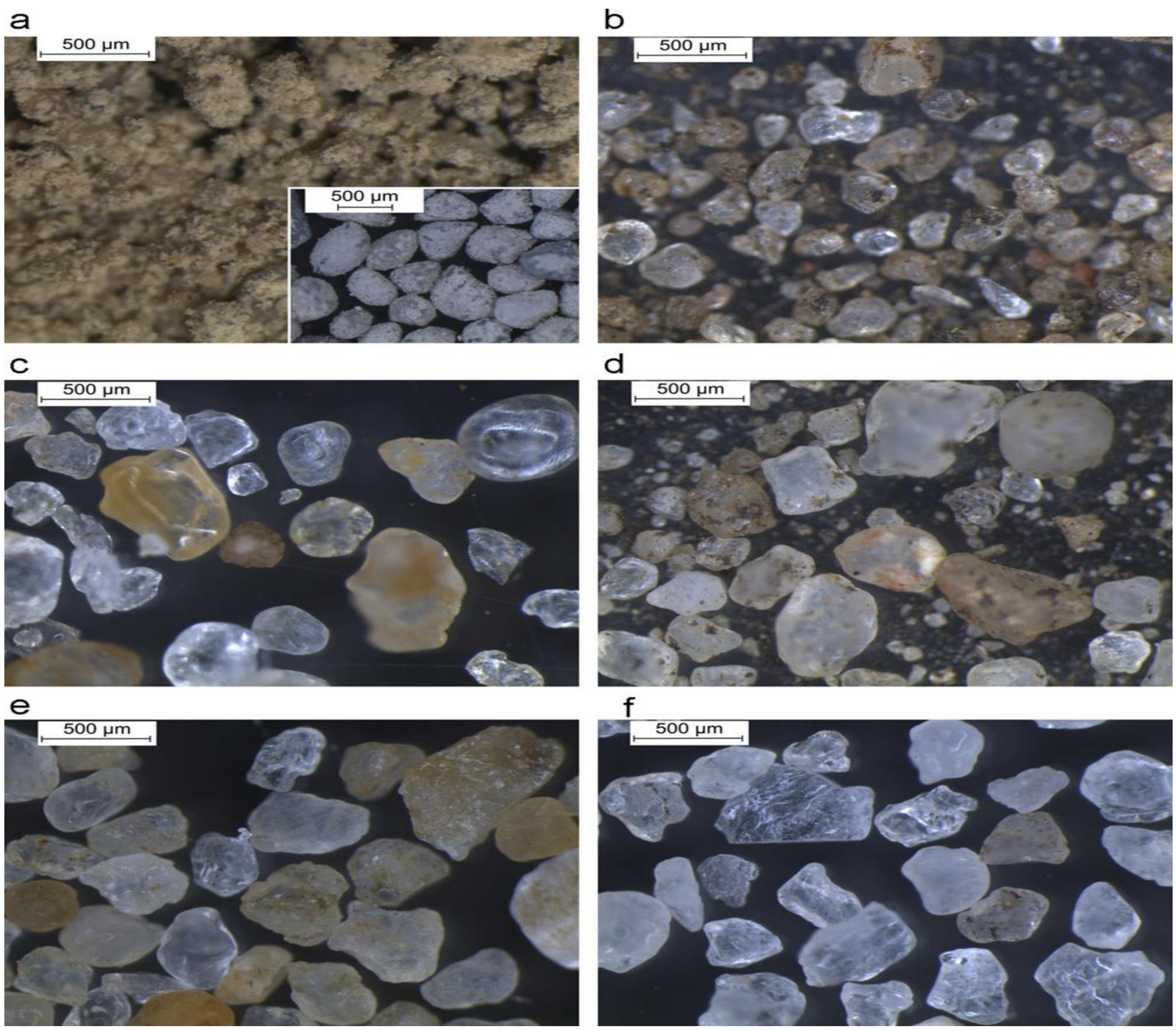

Fig.2 Shows the stereo-microscopic pictures of different sands: (a) Afghanistan, (b) Gambia I, (c) Gambia beach II, (d) Netherlands I, (e) Netherlands beach II and (f) Silversand [12].

Scheffer and Allen, 1988 [11] reported that surface of tillage implements abraded by sandy soils were relatively smooth and more uniform as compared to clay soil, due to the reason which may be that in clay soil, abrasive particles are more held in situ. It was found that in stony soils wear scars were deeper and material had to be torn from the surfaces.

Ferguson et al., 1998 [6] examined the abrasive wear resistance of shares in different South Australian soils. They have chosen five types of soil was selected for research at different moisture levels to find the effect of soil and moisture content on wear behaviour. At Mangalo site (Sandy clay- loam) the wear rate was 4.25 times more with 2% water content than the same soil with 18% water content. Fig. 3 shows the average life span of shares at different sites.

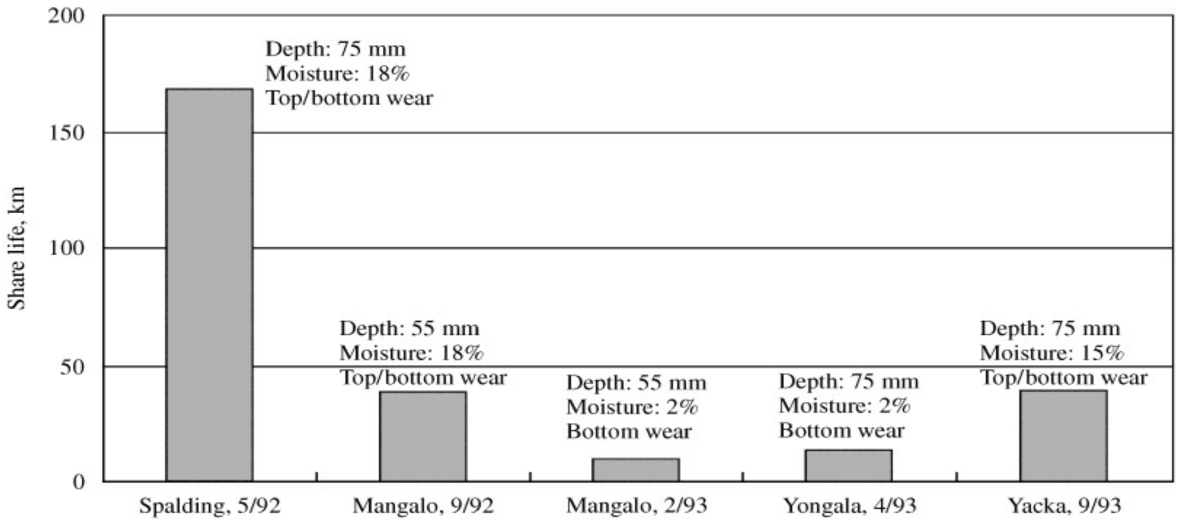

Fig. 3 Shows the average life span of shares at different sites [6].

2.2 Moisture content

Another factor influencing abrasive wear is soil moisture content. According to Miller, 1984 [13] the influence of moisture on the abrasion rate of tillage implements is depending on soil type, being different for sandy soil than clay soil. As reported by Yu and Bhole, 1990 and Baryeh, 2001 [2,14] wear rate of tillage implements increase in sandy soils with increase in moisture content.

Effects of relative hardness and moisture content (7.5, 10, 12.5, 15, 17.5 and 22.5%) on tool wear in soil excavation operation was studied by Mosleh et al., 2013 [15]. In this research it was found that when the moisture content of soil is increased to 10%, the wear of tool increased drastically at maximum level. But this reversed with the further increase of moisture content and reaches saturation at moisture of 22.5% of soil, where the wear of excavation tool is smaller than that experienced in dry soils.

Baryeh, 2001 [14] also found that the wear of a Ghanaian hoe in loamy sand increases linearly with an increase in moisture content. As the moisture content increases, the soil particles are free to move due to that more abrasion wear occurs between tillage tools and the soil particles. In sandy soils, wear rate of tillage implements increases, as the moisture content increases, but reversed in clay and loam soils [1].

Ferguson et al., 1998 and Miller, 1984 [6,13] found that the soil aggregates affects the tillage implements in different soils in Australia. Natsis et al., 2008 [10] report that there is a strong correlation detected between soil type and tool wear for different hardness values of tools. As shown in Fig. 4 wear rate of tillage tools increases at an optimum level, when moisture content increases in clay and loam sand, further increase in moisture content decrease the wear rate of tillage implements, whereas in sandy soil higher wear rates was observed at shares points with increase in moisture content.

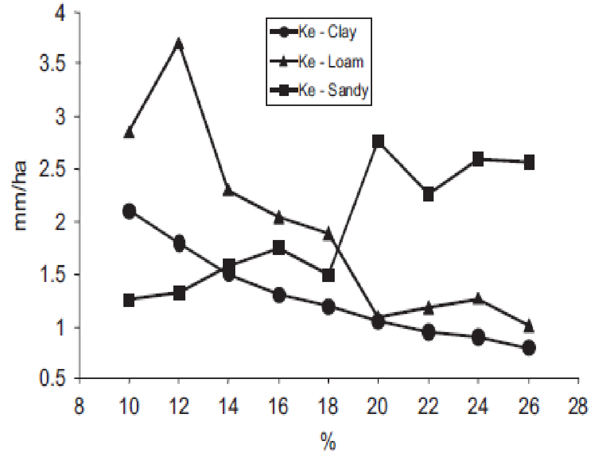

Fig. 4 Share edge wears width v/s soil moisture [10].

2.3 Soil Cohesion

Higher the bulk density of soil more soil compactness, requires higher draft forces for tillage. In randomly compacted soils it is generally accepted that ploughshares behind the tractor wheels wear more than other ploughshare points. As confirmed by Owsiak, 1997 [8] the abrasive wear of tillage implements was 40-100% greater in sandy soil than clay soil. The wear rate of ploughshare behind the tractor wheel track was 17-40% more the outer track points.

According to Lipiec et al., 2002 [16] at various levels of soil compaction, the resistance of penetration increases with decreasing soil moisture content. In a study by [17,18] it is observed that with increase in moisture content there is a reduction in the load support capacity of soil, which results in lower permissible ground pressure.

Fielke et al., 1993 [19] observed 55-73% reduction of wear rate in tillage tools when bulk density had been reduced by a previous pass bat also by 40-50% just due to a change in bulk density from one year to the next year. Richardson, 1967 [9] also reported that wear on a particular tool is subject to the strength of the soil caused by abrasion. Arvidsosn et al., 2004 [20] studied the effect of moisture content on specific draft forces. The researcher found that as the water content decreased cohesion strength of different soils increases and vice-versa. Fig. 5 shows the soil cohesion as a function of moisture content. Draft requirements during tillage were closely related to soil cohesive strength.

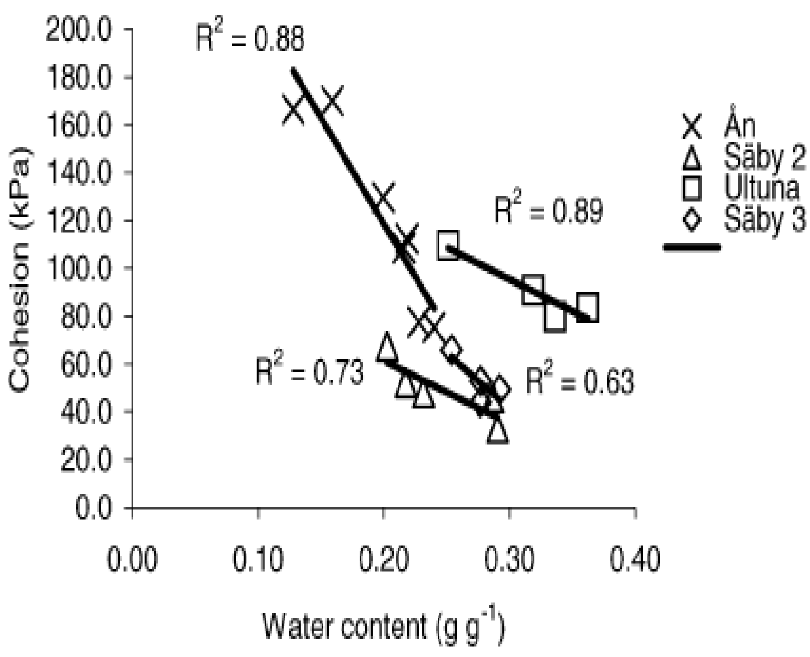

Fig. 5. Soil cohesion as a function of soil water content [20].

As shown in Fig. 6 the graph between cohesion strength v/s specific draft forces were linear for moldboard ploughing, as the cohesion strength increases there is more need of specific draft forces. So, when specific draft forces were higher the great loss in tractor energy and tillage tools was observed. This confirms that soil moisture content is the most important factor influencing the soil compaction processes [21].

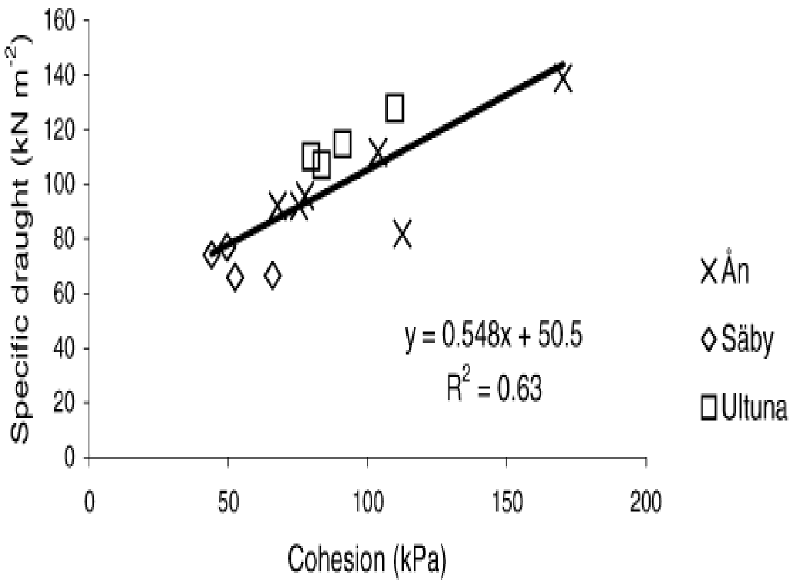

Fig. 6. Specific draft for moldboard ploughing as a function of soil cohesion [20].

3. SUMMERY

- The moisture content plays a vital role in abrasion wear of tillage implements. In the present study from previous literature, it is concluded that in loam and clay soil wear rate of tillage implements decreases as the moisture level increases. On contrary, in sandy soils, wear rate increased with increase in moisture content. Therefore, the selection of right time for tillage enables, when optimum moisture level is present in soil.
- Soil texture and its particle size soil influence the wear rate of tillage implements. It is observed that wear rate of sandy soil is higher than the loamy and clay soils. It also varies on quantity of stone contents and their size.
- With increase in moisture content, cohesive strength of soil particles decreases and vice-versa. Wear of tillage tool behind the tractor wheel wear more than the other share points, due to higher compactness of soil. Cohesion strength of soil directly affects the draft forces and increased fuel consumption of tractor, which results loss of energy.

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