Plant Archives Vol. 26, Supplement 1, 2026 pp.875-880 e-ISSN:2581-6063 (online), ISSN:0972-5210

Plant Archives

Journal homepage: http://www.plantarchives.org

DOI Url : https://doi.org/10.51470/PLANTARCHIVES.2026.v26.supplement-1.117

FIELD BASED WEAR TESTING OF LOCALLY AVAILABLE ROTAVATOR BLADES IN INDIA

Chelpuri Ramulu[1*], M. Arjun Naik[2], Saurabh Dubey[1], Harsha B. R.[1], A. K. Dave[3] and I. Srinivas[4]

[1] K.V.K. Madhopur, DRPCAU Pusa, Bihar, India

[2] A.N.G.R.A.U., Andhrapradesh, India

[3]Department of FMPE, I.G.K.V. Raipur, C.G., India

[4]N.R.M.,Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad India

*Corresponding author E-mail: chepuri.ramulu@rpcau.ac.in

(Date of Receiving : 10-09-2025; Date of Acceptance : 19-11-2025)

ABSTRACT

Tillage is the most basic and energy-intensive agricultural operation in agriculture. Utilizing a plough and cultivators to till land is the most popular technique. In ploughing, soil layer is subjected to various deformations. However, by using moldboard ploughs the upper layer of the soil is not always loosened to desired extent, nor is the proper mixing of the different layers achieved. One potential solution to these issues is the tractor-mounted rotavator. Rotavator under dynamic loading, blades are subjected to fatigue and abrasive wear. Rotavator blade abrasive wear has become a significant issue. It increases the down time and maintenance cost. The objective of this study was to analyses wear loss in field and laboratory. For this study, two distinct makes of L-shaped rotavator blades that were readily accessible locally had been chosen based on farmer preference. The study revealed that there was wide variation in element composition and mechanical as well as micro-structural properties of these rotavator blades, the wear loss percentage of blade1 higher than the blade 2. It was also found in the study blades are which are selected manufactured locally are hardly at par with the standards in terms of material.

***Keywords*: Rotavator, abrasive wear, tillage, hardness and wear loss.

Introduction

Tillage is the most important operation and more energy consumption operation in agriculture. It is done mainly to loosen the soil, to mix with fertilizer and to remove weeds. The implements used for tillage are MB plough, cultivator, disc plough, rotavator …etc. The energy required in wheat cultivation for Tractor drawn cultivator and disc harrow was about 3828 MJ/ha and for rotavator is about 2586 MJ/ha (Singh *et al.*, 2011). From the above statement tractor drawn rotavator is saves 32.4% energy than tractor drawn cultivator and disc harrow in wheat cultivation. The use of the Rotavator (rotary tiller) has become widespread in modern agriculture for seed-bed preparation, residue mixing, and soil conditioning. These implements offer rapid soil pulverization, reduced tillage passes, and improved seed-to-soil contact, thereby contributing to higher cropping efficiency. However, the soil-engaging components especially the blades are subjected to severe abrasive and impact loads. For example, in sandy or stony soils the blades of rotavators wear rapidly, thereby increasing replacement frequency, machine downtime and operating cost (Arya, 2020)

Blade wear in rotavators remains a major bottleneck in achieving efficient mechanized land preparation, particularly in regions with harsh soil textures. The continual material loss from the cutting edges degrades performance, increases fuel and power demand, impairs soil-tool interaction, and elevates operating costs. A study noted that depending on Indian soil conditions, blade edges can wear out after as little as 25–40 hours of field operation (Mandal, 2021). Now a days the adoption of rotavator was risky for farmers due to wearing of soil engaging parts. This wear problem is caused due to when soil engaging parts penetrate into the soil, soil resistance forces, frictional forces etc. acted upon soil engaging parts (Ramulu, 2021) The wear in agricultural machinery is basically abrasive in nature because such tools usually come in contact with the soils which are abrasive due to quartz, stone and sand contents etc. Abrasive wear means removal or displacement of material from solid metallic surface due to pressure exerted by continuous sliding of hard soil particles (Kang *et al.*, 2012). Abrasive wear occurs when hard particles such as sand, stone pieces or hard materials slide or roll over surface with certain pressure all the digging parts of tillers, seeding and excavating machines are exposed to abrasive wear in a non-stationary abrasive mass of soil. An estimation of material loss in cereal cultivation in Turkey indicates that for cultivating an area of 13422 000 hectare twice, an amount of 9700 tonnes of steel is lost due to wear and abrasion and that the energy equivalent of this material loss has been found to be 897 GJ, (Karamis, 1987).

While field trials provide realistic wear conditions, they are time-consuming, costly and difficult to control for variable parameters. In contrast, laboratory testing allows controlled variation of key factors (soil type, moisture content, blade material, speed, depth) and faster comparative evaluation. For instance, a recent study developed a circular soil-bin laboratory rig to simulate abrasive wear of rotavator blades under controlled conditions. By combining laboratory and field testing, the behavior of blade wear can be better characterized and extrapolated to real operational conditions (Mandal *et al.*, 2013).

In light of the above, the purpose of this paper is to conduct both laboratory and field wear testing of rotavator blades. The combined approach will enable better recommendations for blade design, material selection, surface treatment and operating practice to enhance service life and cost-effectiveness of rotavator.

Material and Methods

Selection of blades and their properties

In our study, the decision to select the L-shaped blade for testing was based on several technical and practical considerations relevant to the operational conditions of a rotavator. First, among the three common blade geometries namely L-shaped, C-shaped and J-shaped the L-shaped design is widely used in Indian and similar agrarian environments because it offers superior performance in trashy and residue-rich fields, with better weed cutting and lower tendency to clog the rotor (Mandal *et al.*, 2013).

A preliminary survey was conducted in the region to know the popularity of rotavator and types of blades being used by farmers. The review was also done to have the stock of situation in reference to type of blades. It was found that L types of blades are more in numbers in the region with the two make of rotavators i.e. blade 1 and blade 2. The blade 2 and blade 1 are shown as a and b in the Fig 1.

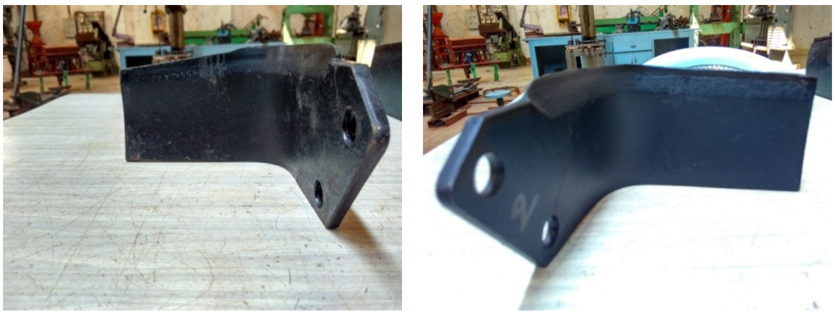

Fig. 1: Selected rotavator blades

Composition also determines how the material responds to the soil environment: e.g., presence of hard particles, moisture, impact loads, and chemical environment. Some materials may form harder surface layers through in-service work hardening; others may degrade due to microcracking if composition is not appropriate. Many agricultural tillage tool studies (including on rotavator blades) report that blades made from boron steel or high-carbon alloys perform better in wear tests because of their better composition/heat treatment. For example, one study on rotavator blades found that the boron steel blade had higher hardness and lower wear rate compared to medium carbon steel. (More *et al.*, 2022). The composition of these blades was determined by using optical emission spectrometer. As per the standard methodology, it is necessary to have a sample piece of blades having at least 1 sq inch area for the purpose of element analysis.

Hardness

Hardness refers to the material's ability to resist indentation, scratching or permanent plastic deformation. In abrasive wear scenarios (such as blades cutting through soil with hard particles), a higher hardness generally correlates with lower wear rate. For example, if the material of the blade is softer than the abrasive particles in the soil (sand, quartz, etc.), then the blade will suffer high wear. Thus, when testing rotavator blades, measuring the hardness of the blade material (surface and perhaps sub-surface) gives you a key indicator of wear resistance and you should correlate hardness variations (for different materials/material treatments) to experimentally measured wear rates (Vlădutoiu, 2023). In this study the hardness was measured by using Rockwell hardness tester. Testing is typically performed on flat or cylindrical samples. Smooth parallel surfaces, scale and gross contamination, are required for testing. The size of samples about 1 inch diameter and 7.5mm thick were tested. Samples 6 in. (150 mm) thick or larger can be accommodated. The minimum sample size depends on the sample hardness and test scale. Cylindrical samples are as small as 1/8 in. (3 mm) in diameter, and thin sheets 0.006 in. (150 µm) thick, are the minimum size for testing.

Microstructure

The internal structure of the metal (grain size, phase distribution, presence of carbides/inclusions, residual stresses, etc.) influences how the material behaves under abrasive/impact loads. In the context of rotavator blades, microstructure is important because the blade is subject not only to steady abrasion, but to impact from stones, clods, roots, and a mixture of soil particles. The microstructure study was observed by using SEM (scanning electron microscope). The size of samples used for measurement of microstructure is about $10x15x7mm^3$, the sample was should be prepare like mirror surface prior to observing with SEM. The sample which is to be tested was polished by using different silicon carbide papers of different grits 180,200, 400, 800, 1200 and final finishing was done by using mechanical polisher. After this step the sample was etched by 100g nital solution (3-5g H2So4 and 95-97g ethanol). The microstructure study was observed both the blades before and after operation.

Field condition and location

An area of 4 ha was selected for testing of blades at Hayatnagar Research farm CRIDA Hyderabad. The field was free from any cultivation. The general condition of soil in this area was hard, dry and clay loam soils with stones. The bulk density of soil was $1.35g/cm^3$. The whole field was divided in two parts for testing of Blade 1 and Blade 2 separately. The rotavator was operated for three different durations i.e. 2, 7.5 and 10 hour. The time period was selected looking to field condition which was fully dried, which allows to judge the performance. The same time of duration was also suggested in review of literature, if field is fully dried.

Percentage Wear Loss (weight and volume based)

The high abrasiveness of the soil and high impact load on the blade surface results in a significant acceleration of the wear of the blades. The experiments were conducted on February 2016. The rotavator was driven by a tractor (5245 DI Massey Fergusson, Planetary drive, 47 HP, 3-cylinder, forced water cooled) through its power take-off (PTO) shaft at the speed of 540 rpm@1790Erpm. Average traveling speed was about 1.21 km/h, yielding theoretical field capacity of about 0.72 acre/h. The average depth penetrated in the soil about 7.4cm and fuel consumption was 4.65 lit/hr.

This test blades were fitted onto the tractor mounted rotavator in place of the standard blades randomly and the field experiment was carried out on a test field for a 10h. In this study the readings were taken at different time intervals i.e. 2.0h, 7.5h and 10h for measuring wear loss on weight and volume based. The weight readings were taken by using electronic weigh machine before operation and after operation.

The wear of the blades was assessed by weighing each blade before and after each experimental period to determine the wear loss. The percentage of wear (weight based) loss defined as the ratio of differences of rotavator blades weights before and after experimental period divided by weight of rotavator blades before experimental period. A digital weighing balance (Calon make, range: 0-3 kg, least count: 0.1g) was used for measuring weights of samples.

$$\text{Wear loss (weight based) (\%)} = \frac{\begin{matrix}\text{Weight before} \\ \text{the operation}\end{matrix} - \begin{matrix}\text{weight after} \\ \text{the operation}\end{matrix}}{\text{weight before the operation}} \times 100 \quad (1)$$

Volume losses of blade were also assessed by measuring the volume of each blade before and after each experimental period to determine the volume loss. For measuring volume of the blades one bucket of 20 litres capacity with scaled on it was taken. Then it was filled up to 5litres of water. After this we kept the blade into that bucket. Then the volume of that bucket would be increased. Then taken the reading after volume increased. The volume of blade would be the volume of water after keeping blade minus the volume of water before keeping blade. Likewise, we have measured the volume of all the treatments before and after field operation.

Percentage of wear loss (volume based) was defined as the ratio of differences of rotavator blades volume before and after experimental period divided by volume of rotavator blades before experimental period as shown in Fig 2. Percentage of wear loss was used as indicator of amount of wear or performance of blade. Lower the percentage of wear, the performance more or lesser amount of wear.

$$\text{Wear loss (Volume based) (\%)} = \frac{\text{Volume before the operation} - \text{volume after the operation}}{\text{volume before the operation}} \times 100 \quad (2)$$

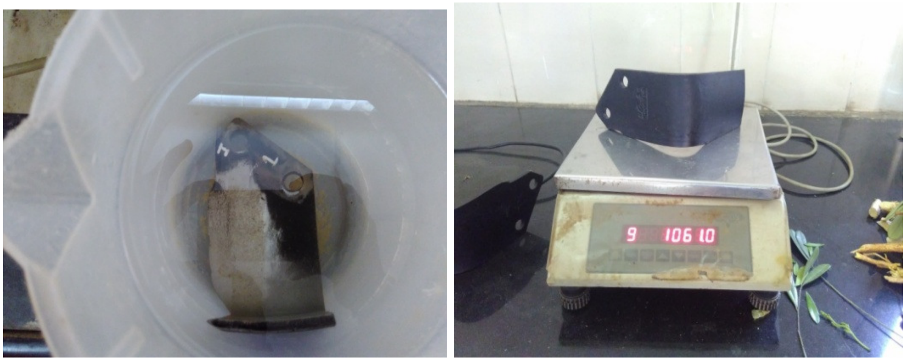

Fig. 2 : A view of measurement of volume and weight of blade

Results and Discussion

In this study two types of rotavator blades namely Blade 1 and Blade 2 were selected for determination of element composition, hardness and wear characteristics. The composition of these blades was determined by using optical emission spectrometer. The chemical composition is shown in Table 1. The control blades were used for tillage operations and the wear loss on weight and volume basis were recorded. The results of control blades are shown in Table 2. The hardness of blades was also measured to know the wear characteristics the results were shown in Table 3.

Blade 2 has the more wear loss compared to blade 1 as shown in Fig 3., it indicates that blade 1 has the more wear life than blade 2. The results shown that the hardness of blade 2 was more than blade 1. The table 1 shows that blade2 has the Cr and Si more than blade 1 Cr and Si composition. Chromium has significant effect on fatigue life. Higher hardness and strength in boron and chromium steel is due to mixed martensite-bainitic microstructure (Bhakat *et al*., 2004). Blade 1 has higher wear resistance and hardness it might be due to these above-mentioned statements.

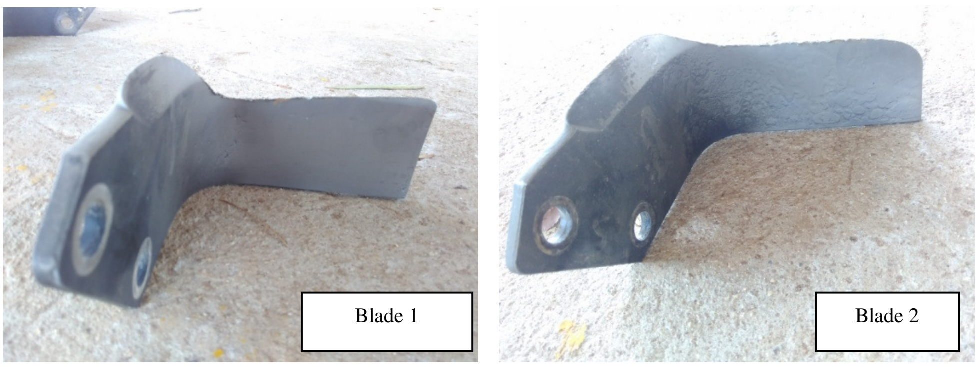

Fig. 3: Condition of blades after field operation

Table 1 : Element composition of selected rotavator blades

Blade / Parameter	Unit, %								
	C	**Si**	**Mn**	**S**	**P**	**Cr**	**Mo**	**Ni**	**Fe**
Blade 1	0.29	0.22	1.30	0.012	0.024	0.37	0.05	0.19	97.544
Blade 2	0.28	0.32	1.33	0.014	0.038	0.38	0.03	0.14	97.468

Table 2 : Wear loss of selected rotavator blades on weight and volume basis

Blade	Wear loss, % per hour	
	Weight basis	Volume basis
Blade 1	1.810	5.660
Blade 2	1.802	3.729

Table 3 : Hardness of selected rotavator blades

Blade	Hardness, HRA
Blade 1	44.66
Blade 2	45.33

Microstructure study of Blade 1 blades

The microstructures of Blade 1 and Blade 2 were shown in Fig 4 and Fig 5. The both rotavator blades have martensitic structure on their surface, it was shown in Fig 4(a) and Fig 5(a). Rough wear tracks also observed in both blades, it was shown in Fig 4(b) and Fig 5(b). Blade 2 has the shows the marten sic structures clearly than blade 1. Marten sic structure improve the wear resistance of blades. In this study also blade 2 has higher wear resistance than blade 1.

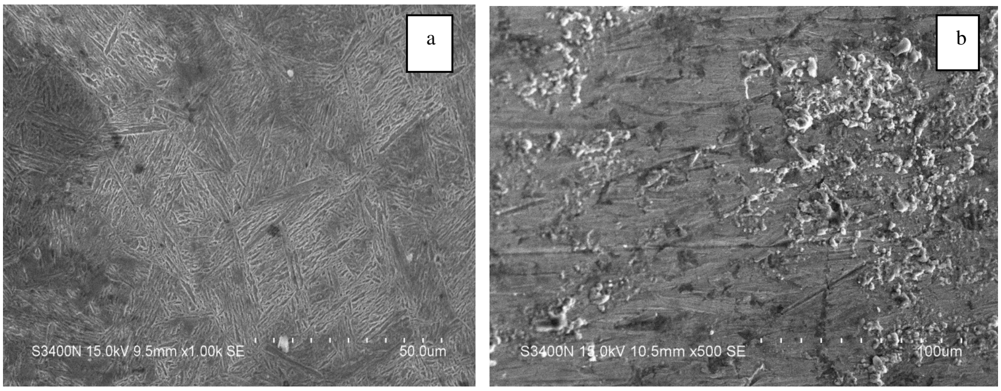

Fig. 4: Micro structure of control Blade 1 a) before and b) after operation

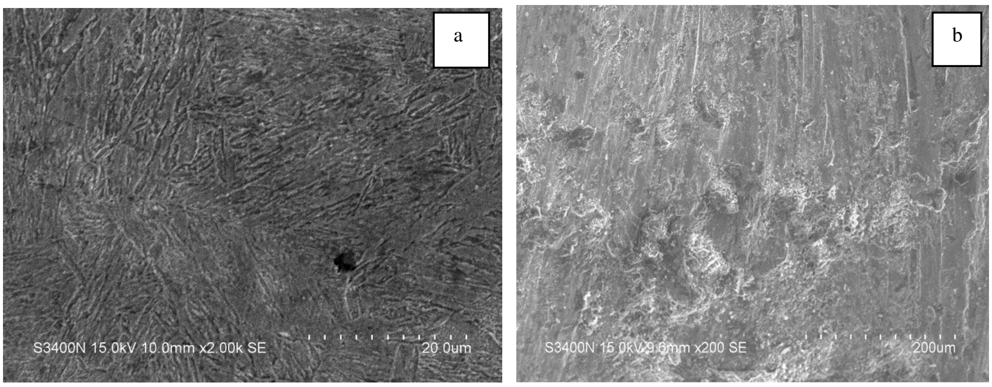

Fig. 5: Micro structure of Control Blade 2 a) before and b) after operation

Conclusion

After conducting the above study, the study was concluded that

1. The wear loss on weight and volume basis was on higher in case of blade 1 comparison to blade 2
2. The hardness was also on lower side in case of blade 1. It concludes that blade 2 having lower wear loss and higher hardness value.
3. From the microstructure study also blade 2 has higher wear resistance than blade 1.
4. From the comparison of both elements composition blade 2 has Si, P and Cr content more than blade 1 it might be concluded that Si, P and Cr composition increases wear resistance increases. (Bhakat *et al.*, 2004)

Acknowledgements

The authors gratefully acknowledge the Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, for providing valuable technical support during the course of this study.

The authors express their sincere gratitude to the Central Research Institute for Dryland Agriculture (CRIDA), Hyderabad, for providing financial support and necessary resources that enabled the successful completion of this research work.

Authors' Contributions

Authors may use the following wordings for this section: "'Chelpuri Ramulu and M Arjun Naik' designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. 'Saurabh Dubey, Harsha B R, A K Dave' and 'I Srinivas' managed the analyses of the study. 'Chelpuri Ramulu' managed the literature searches. All authors read and approved the final manuscript."

References

Arya, R., Kumar, R. and Pateriya, R.N. (2020). Comparative study of wear characteristics and material composition analysis of different types of rotavator blade. *Int. J. Curr. Microbiol. Appl. Sci.*, **9**, 390–401.

Bhakat, A.K., Mishra, A.K. and Mishra, N.S. (2007). Characterization of wear and metallurgical properties for development of agricultural grade steel suitable in specific soil condition. *Wear*, **263**, 228–233.

Kang, A.S., Grewal, J.S., Jain, D. and Kang, S. (2012). Wear behavior of thermal spray coatings on rotavator blades. *J. Therm. Spray Technol.*, **21**, 355–359.

Karamis, M.B. (1987). Energy losses resulting from tillage tool wear in Turkish agricultural fields. In: *Third International Symposium on Mechanization and Energy in Agriculture: Proceedings*, Izmir, Turkey, October 26–29, pp. 211–219.

Mandal, S.K., Bhattacharyya, B., Mukherjee, S. and Chattopadhyay, P. (2013). Design & development of rotavator blade: Interrogation of CAD method. *Int. J. Sci. Res. Knowl.*, **1**, 439.

Mandal, S.K., Bhattacharyya, B., Mukherjee, S. and Karmakar, S. (2021). Design optimisation of rotary tiller blade towards service life enhancement. *J. Manuf. Eng.*, **16**, 115–123.

More, M.S., Bastewad, T.B., Sapkale, P.R., Bhangare, S.C. and Patil, M.R. (2022). Studies on wear characteristics of surface hardened tractor drawn rotavator blade. *Int. J. Agric. Eng.*, **15**, 215–222.

Ramulu, C., Naik, M.A., Dave, A.K. and Srinivas, I. (2021). Cost economics of electro spark coated rotavator blades. *Carbon*, **100**, 5–6.

Singh, D. and Saxena, A.C. (2011). Characterization of materials used for rotavator blades. *Agric. Eng. Today*, **35**, 10–14.

Vlăduţoiu, L.C., Chişiu, G., Tudor, A., Vlăduţ, N.V., Fechete Tutunaru, L., Marin, E. and Grigore, I.A. (2023). Tribological study of chisel knives in sandy soil. *Agric.*, **13**, 1235.