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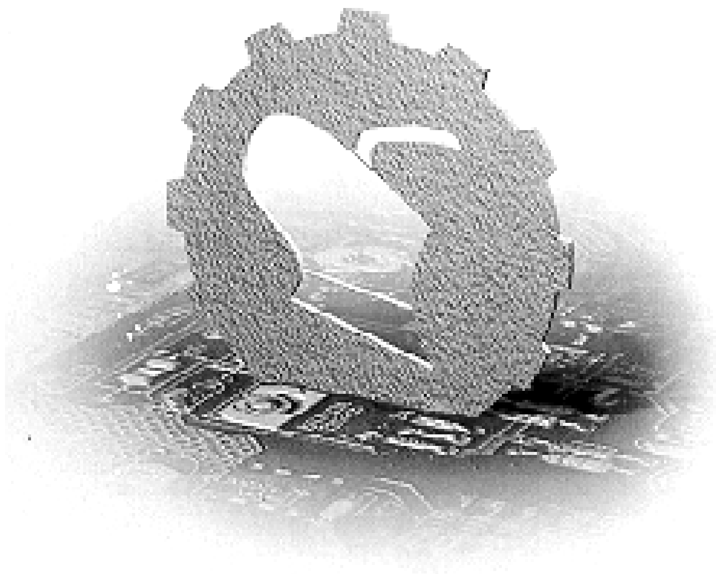

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HIDRAULIČKI SIMBOLI - DEO III: VENTILI

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Sažetak: Slično ljudskom zdravlju, značaj hidraulike ponekad postaje vidljiv samo u njenom odsustvu. Slike i motivi radnika u poljoprivredi iz prošlih vremena i vekova mogu izgledati privlačno samo na umetničkim slikama. U stvarnosti, to je bio veoma naporan i ponekad prilično opasan posao. Uvođenje hidraulike u konstrukcije savremenih poljoprivrednih mašina za poljoprivrednu proizvodnju, učinilo je poljoprivredu fizički manje zahtevnom za radnike, ali i efikasnijom, što je od posebne važnosti za obezbeđenje hrane rastuće svetske populacije tokom XX veka. Postizanje visoke efikasnosti, pouzdanosti i dugog radnog veka ovih sistema zahteva naprednu dijagnostika i otklanjanje kvarova, redovno održavanje i pažljivo korišćenje svakog hidrauličkog sistema, a to je moguće samo uz dobro poznavanje funkcionalnih principa svih elemenata, njihovih veza i sistema u celini. Međutim, savremeni hidraulički sistemi poljoprivrednih mašina često su veoma komplikovani, a konstrukcija njihovih komponenata previše kompeksna za detaljno grafičko predstavljanje u sastavu pripadajuće hidrauličke instalacije. Zato, umesto detaljnog predstavljanja komponenata, koriste se odgovarajući šematski dijagrami. Ovaj tekst predstavlja logičan nastavak prvog i drugog dela rada, posvećenih opštim simbolima, oznakama mernih instrumenata i indikatora (prvi deo), kao i pumpama i izvršnim elementima (drugi deo). Treći deo rada prikazuje hidrauličke simbole elemenata za upravljanje – hidrauličke ventile. Grafičke simboličke oznake upravljačkih komponenata su definisane ISO standardima.

Ključne reči: *hidraulika, sistem, simbol, šema, upravljački hidraulički element, ventil, razvodnik*

[*] Kontakt autor. E-mail adresa: epetrodr@agrif.bg.ac.rs. Rad je deo aktivnosti projekta broj TR 31051 -*Unapređenje biotehnoloških postupaka u funkciji racionalnog korišćenja energije, povećanja produktivnosti i kvaliteta poljoprivrednih proizvoda“*, koji finansira Ministarstvo prosvete, nauke i tehnološkog razvoja Republike Srbije.

UVOD

Hidraulička tehnologija je prvobitno uvedena u poljoprivredu, doslovno, da zameni konje. Veliki, teški konji zamenjeni su traktorima, koji su zavisili od hidraulike, kako interno (za kočenje i upravljanje) tako i eksterno (za podizanje ili prenos snage ka agregatiranim priključnim mašinama). U mnogim slučajevima i dalje je bio potreban određeni stepen ljudske intervencije u toku rada. Šta više, u nekim slučajevima to je moglo biti od suštinskog značaja.

Ranije konstrukcije traktora su zahtevale pažljivu kontrolu svih aktivnosti (kao što su npr. podizanje ili oranje) od strane ljudi. Međutim, čak i tada je postojao relativno visok stepen nepreciznosti u vođenju odgovarajućih radnih operacija. To je ostavljalo dve mogućnosti. Prva se svodila na prihvatanje određenog nivoa gubitaka. Druga je zahtevala dodatni ljudski (manuelni) rad, nakon što je traktor završio većinu posla, koji se u suštini obično svodio na čišćenje i obradu neadekvatno ili potpuno neobrađenih delova zemljišta ili useva.

Međutim, sa razvojem tehnologije, hidraulika je, kombinovana sa naprednom elektronikom, omogućavala fino podešavanje pritiska i protoka radne tečnosti (hidrauličkog ulja), koje prevazilazi veštinu ljudskih rukovaoca. To je rezultiralo intenzivnim razvojem poljoprivrednih mašina, kao što su npr. precizne sejalice, koje ne samo da mogu dostaviti seme na optimalan način preko promenjivog polja, već i istovremeno dostaviti i đubrivo. Ovo semenu pruža mnogo veće šanse za optimalan rast i razvoj do pune zrelosti, što rezultira boljim prinosom i smanjenjem troškova, a to se može preneti i na krajnje cene ka potrošačima.

Ranija hidraulička tehnologija imala je fiksni radni pritisak i protok. U zavisnosti od situacije, ponekad je bilo moguće promeniti parametre, ali je to zahtevalo intervenciju operatera. Moderni traktori i druge poljoprivredne mašine imaju znatno veći hidraulički kapacitet od svojih prethodnika sa znatno više ugrađenih ventila (videti [6]). U isto vreme, tradicionalno kardansko vratilo je u velikoj meri ustupilo mesto hidrauličnim cevima i crevima koja direktno prenose energiju od hidraulične pumpe (videti [5]) ka priključnoj mašini, što omogućava jednostavnije rukovanje i garantuje visoku pouzdanost. Upotreba elektronskih kontrola omogućava veliku preciznost, smanjujući gubitke i time troškove. Ukratko, kombinacija hidraulike i elektronike omogućila je poljoprivredi da pređe sa ljudskog radnika na donošenje najbolje odluke o tome šta je potrebno mašini koja koristi ogromne količine podataka od senzora da bi odlučila šta je potrebno i kako da se prilagođava.

Povezivanje „snage“ hidraulike sa preciznošću elektronike otvara niz mogućnosti. Na najprimitivnijem nivou, može se jednostavno koristiti za povećanje efikasnosti rada poljoprivredne mehanizacije, čime se smanjuje utošak goriva, a nekada i radnog vremena. Na složenijem nivou, može se koristiti za povećanje opsega zadataka koje poljoprivrene mašine mogu obavljati, Time se, između ostalog, stvaraju uslovi za razvoj mikro-poljoprivrede, kao sredstva uzgoja u kojem senzori u polju pružaju precizne informacije o uslovima u svakom delu zemljišta. Zahvaljujući obilnim i tačnim informacijama, poljoprivrednici mogu optimizovati proizvodne procese sa najvećim mogućim stepenom preciznosti i time povećati obim i kvalitet finalnog proizvoda, smanjiti troškove i povećati dobit.

Zato je savremena poljoprivredna tehnika tesno povezana sa širokom lepezom različitih elektronskih i hidrauličkih uređaja i sistema [14]. Ilustracije radi, mogu se navesti različite oblasti poljoprivredne mehanizacije, kao što su npr. prenos snage i upravljanja uljnim hidrauličkim sistemima [5], [6], [14], navodnjavanje [9], [10], zaštita bilja [4], [7], [13], sejalice itd.

Željene funkcije i bezbedan rad svih hidrauličkih sistema, pa i onih primenjenih u poljoprivrednoj tehnici, ostvaruju se ugradnjom upravljačkih elemenata – hidrauličkih ventila. Upravljanje hidrauličkim sistemom ostvaruje se podešavanjem pritiska i protoka, kao i sprečavanjem ili otvaranjem toka radne tečnosti u određene delove pripadajućeg sistema.

Ventili se prema nameni dele u četiri osnovne grupe:

a) ventili za pritisak;
b) ventili za protok;
c) nepovratni ventili i
d) razvodni ventile (razvodnici).

Sledeći pristup primenjen u prvom [11] i drugom [12] delu rada, a u skladu sa referencama [6], [8] i [15], u ovom (trećem) nastavku rada o hidrauličnim oznakama prikazani su najvažniji simboli hidrauličkih ventila. Ova grupa simbola je standardizovana međunarodnim ISO standardima [1], [2], [3] i nacionalnim standardima.

SLOVNE OZNAKE PRIKLJUČAKA HIDRAULIČKIH VENTILA

Pored grafičkih simboličkih oznaka, u okviru hidrauličkih šema se redovno primenjuju i standardizovane slovne oznake odgovarajućih priključaka, koje simbolički prikazanu hidrauličku komponentu povezuju sa ostalim elementima pripadajućeg hidrauličkog sistema, kao što su npr. hidraulička pumpa, aktuator, glavni ili pomoćni rezervoar tečnosti itd. Ove slovne oznake su prikazane u tabeli 1.

Tabela 1. Slovne oznake priključaka u hidraulici.

Table 1. Letter designations of hydraulic connectors.

P	Ulazni priključak potisnog voda pumpe (engl. *pump*), sa radnom tečnošću povišenog pritiska.
T	Priključak cevovoda za odvod-dovod tečnosti ka rezervoaru (engl. *tank*).
A, B, C	Izlazni priključci radnih vodova, koji vode ka potrošačima.
X, Y, Z	Priključci upravljačkih vodova.
L	Priključak pomoćnog voda - odvoda prodrlog ulja iz komponente u pomoćni rezervoar. Ovaj rezervoar se ugrađuje ukoliko je glavni hidraulički rezervoar udaljen.

GRAFIČKI SIMBOLI HIDRAULIČKIH VENTILA ZA PRITISAK

U ovoj glavi su tabelarno predstavljene osnovne grafičke simboličke oznake većine komercijalno raspoloživih tipova hidrauličkih ventila, označenih kao “ventili za pritisak”, koji nalaze primenu u svakodnevnoj tehničkoj praksi. Ova kategorija hidrauličkih ventila predstavlja upravljačke elemente pripadajućih hidrauličkih sistema, koji omogućavaju održavanje i podešavanje pritiska u hidrauličkom sistemu ili nekom njegovom delu, te predstavljaju elemente za upravljanje i za regulaciju pritiska radne te;nosti. Prema funkciji dele se u nekoliko podgrupa:

a) ventile za ograničavanje pritiska,

b) redosledne ventile i

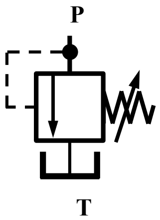
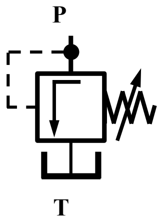
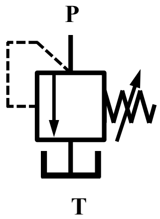
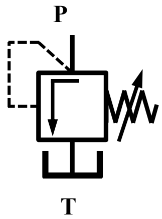
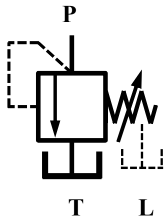
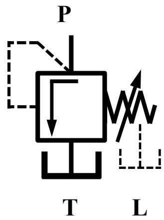
c) redukcione ventile.

Ventili za ograničavanje pritiska u najvećem broju slučajeva obavljaju funkciju sigurnosnih ventila, sprečavajući porast pritiska u sistemu iznad predviđene (dozvoljene) vrednosti. Normalno su zatvoreni. Otvaraju se kada pritisak na ulaznom priključku visokog pritiska koji dolazi od pumpe (**P**) premaši zadatu vrednost i višak tečnosti prelivnim vodom sprovode u rezervoar (**T**). Zatvaraju se kada pritisak padne ispod vrednosti zadate podešavanjem dužine sabijene opruge pomoću zavrtnja. Tečnost iskorišćena za hidrauličko upravljanje ventilom se vraća u glavni hidraulički rezervoar (**T**), ili u pomoćni rezervoar (**L**).

Grafičke simboličke oznake podesivih hidrauličkih sigurnosnih ventila prikazane su u tabeli 2. Svaki ventil iz ove grupe je opremljen elastičnom oprugom, čija se dužina, odnosno deformacija, mogu podešavati pomoću zavrtnja. Dejstvo opruge na zatvarački element opisuje Hukov zakon, koji povezuje relativne deformacije elastičnih tela nastale dejstvom spoljašnjih sila sa unutrašnjim naponima: sabijanjem ili rasterećenjem opruge se povećava ili smanjuje rezultujuća sila kojom ta opruga deluje na radni element ventila. U zavisnosti od intenziteta rezultujuće sile opruge, podešene zavrtanjem ili odvrtanjem regulacionog zavrtnja, podešava se veličina pritiska otvaranja sigurnosnog ventila, a time i maksimalni pritisak u hidrauličkom sistemu ili nekom njegovom delu.

Tabela 2. Simboli osnovnih ventila za ograničenje pritiska radne tečnosti u hidrauličkom sistemu, sa podesivom oprugom i direktnim spoljašnjim ili unutrašnjim upravljanjem.

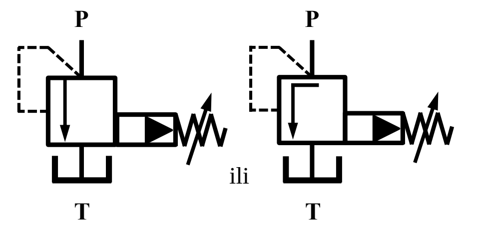
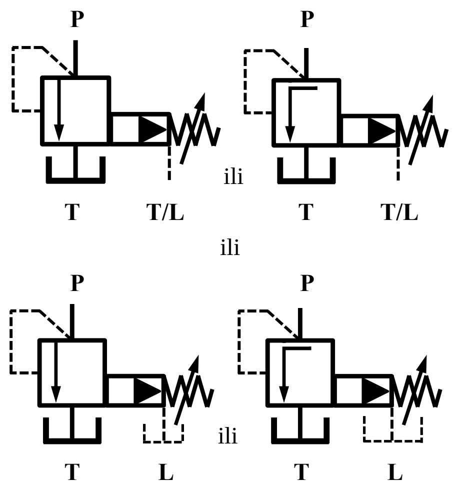
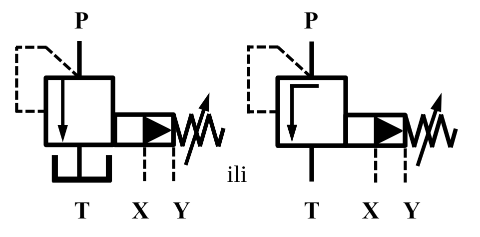
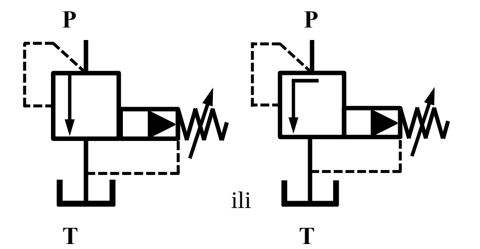
Table 2. Symbols of basic relief valves with adjustable spring and direct external or internal operation.

 ili 	**Sigurnosni ventil sa podesivom oprugom i direktnim eksternim upravljanjem.**
 ili 	**Sigurnosni ventil sa podesivom oprugom i direktnim internim upravljanjem.**
 ili 	**Sigurnosni ventil sa podesivom oprugom, direktnim internim upravljanjem i spoljašnjom drenažom.** *Tečnost iskorišćena za upravljanje radom ventila se odvodi u pomoćni rezervoar preko priključka **L**. Ako je glavni rezervoar u blizini, ista tečnost se može odvesti i u njega – tada se drenažni priključak obeležava sa **T**.

Grafičke simboličke oznake različitih konstruktivnih varijanti dvostepenih sigurnosnih ventila za ograničenje pritiska sa direktnim upravljanjem i podesivom oprugom prikazani su tabeli 3. Kod svih ovih ventila se kombinuju različite varijante hidrauličkog upravljanja sa mehaničkim upravljanjem, koje se ostvaruje uz pomoć podesive elastične spiralne opruge.

Tabela 3. Simboli dvostepenih sigurnosnih ventila sa direktnim upravljanjem i podesivom oprugom.

Table 3. Symbols of two-stage relief valves with direct operation and adjustable spring.

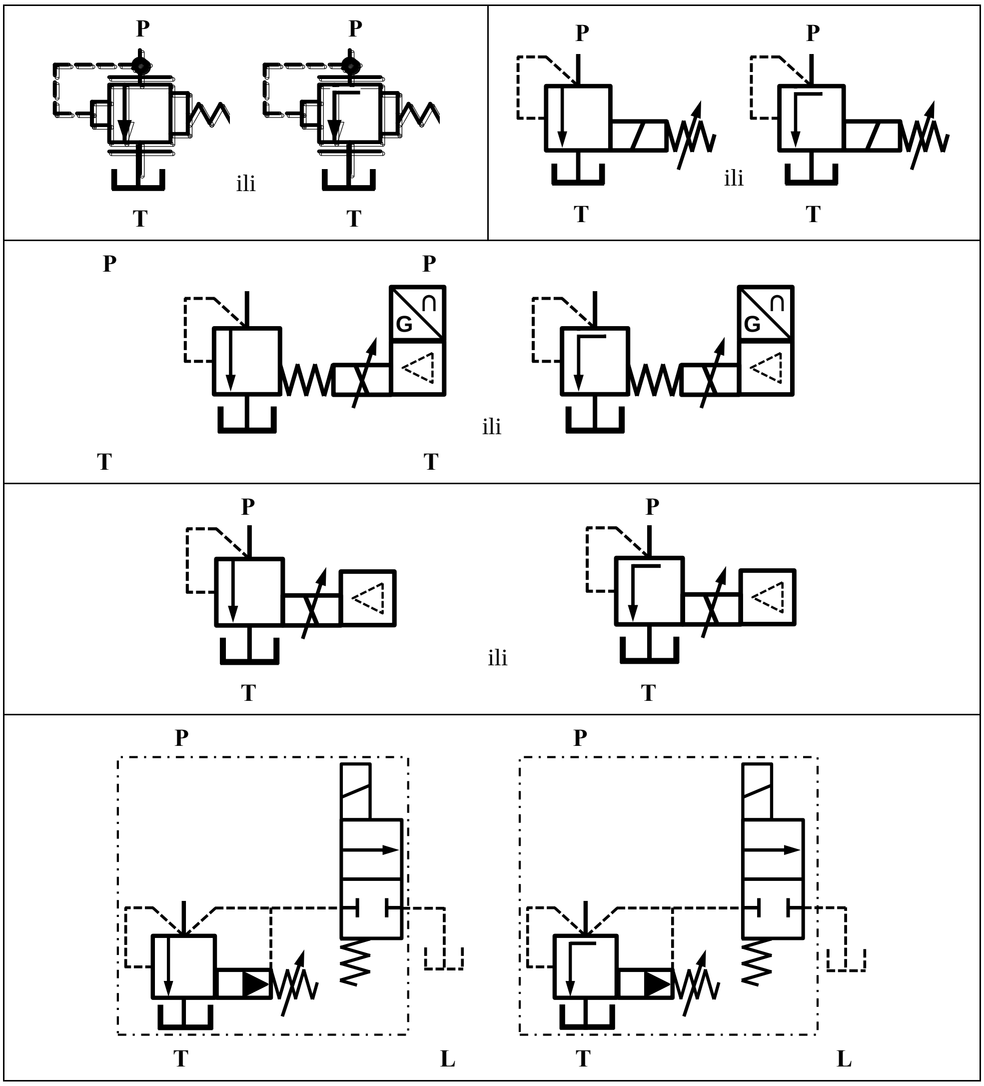
Dvostepeni sigurnosni ventili sa direktnim upravljanjem (dejstvom) i podesivom oprugom	
	
	
	

Nasuprot sigurnosnim ventilima sa jasno definisanim konačnim brojem (najčešće dva) mogućih fiksnih operativnih položaja radnog zatvaračkog elementa (organa), u savremenoj tehničkoj praksi se takođe široko primenjuju i tzv. proporcionalni sigurnosni ventili. Simboličko predstavljanje različitih varijanti proporcionalnih sigurnosnih ventila grafički je ilustrovano tabelom 4.

Ovi ventili ograničavaju pritisak radne tečnosti u pripadajućoj liniji hidrauličkog sistema na vrednost proporcionalnu upravljačkom električnom signalu. Ovaj signal se generiše automatski od strane odgovarajućeg mikrokontrolera, a ređe i manuelno od strane rukovaoca. Da bi se omogućio proporcionalni odziv ovih ventila, usklađen sa upravljačkim električnim signalom, neophodno je konstruktivno rešenje koje omogućava kontinualnu promenu (pozocioniranje) položaja njihovih radnih elemenata, pa ih u anglosaksonskom govornom području nekada nazivaju i ventili sa kontinualnim pozicioniranjem radnog elementa (*engl. valves capable of infinite positioning*).

Tabela 4. Simboli proporcionalnih ventila za ograničenje pritiska.

Table 4. Symbols of proportional relief valves.

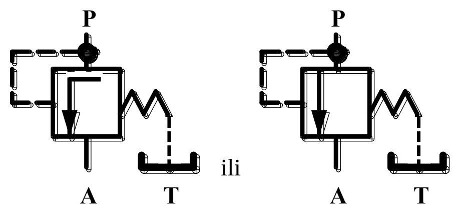


Treba napomenuti da se osnovni ventili ove grupe po pravilu kombinuju sa drugim dodatnim elementima: hidrauličnim (npr. razvodnicima), mehaničkim (npr. oprugama) i električnim elementima (npr. elektromagnetima). Imajući u vidu da je njihovo električno upravljanje (aktiviranje) realizovano pomoću ugrađenih elektromagneta, oni se prema nekim literaturnim izvorima i proizvođačkim katalozima označavaju i kao elektromagnetni hidraulički sigurnosni ventili.

Redosledni ventili su poznati i kao pritisni uključni, pritisni isključni ili samo uključni ili isključni ventili, zavisno od funkcije. Njihova konstrukcija i funkcionisanje su slični konstrukciji i načinu funkcionisanja ventila za ograničenje pritiska. Zadatak ove grupe ventila je da, pri određenom nivou pritiska na ulazu ventila (**P**), uključuju ili isključuju iz rada predviđeni deo hidrauličkog sistema. To ostvaruju uključivanjem ili isključivanjem njegovog napajanja radnom hidrauličkom tečnošću, odnosno otvaranjem ili zatvaranjem protoka ka izlazu (**A**) koji je povezan sa nizstrujnom linijom sistema. Postoji niz različitih konstruktivnih rešenja, u kojima se kombinuje direktno ili indirektno upravljanje, sa upravljanjem pomoću spoljašnjeg ili unutrašnjeg pritiska ili daljinski. Isključni ventil, čijim radom se upravlja pomoću spoljašnjeg pritiska, praktično se ne razlikuje od ventila za ograničenje pritiska. Radna tečnost upotrebljena za indirektno aktiviranje ventila vraća se drenažnim cevodom u rezervoar (**T**). Simboli ovih ventila prikazani su tabeli 5.

Tabela 5. Simboli redoslednih ventila.

Table 5. Symbols of sequence valves.

 	**Redosledni ventil.**

Grafički simboli različitih tipova redukcionih ventila su prikazani u tabeli 6. Ventili iz ove grupe se nazivaju još i ventili za umanjenje pritiska ili regulatori pritiska. Njihov osnovni zadatak je održavanje približno konstantne zadate vrednosti izlaznog pritiska iz ventila, niže vrednosti u odnosu na veći ulazni pritisak. Hidraulička tečnost konstantnog sniženog izlaznog pritiska napaja jedan ili vise nizstrujno postavljenih aktuatora. Veličina tog pritiska se može podesiti prema potrebama aktuatora. Zato se vrednost izlaznog pritiska podešava sa nizstrujne strane ventila (ka aktuatoru).

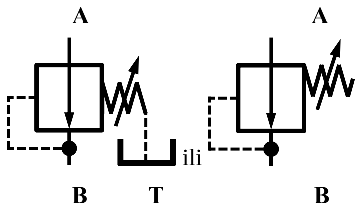
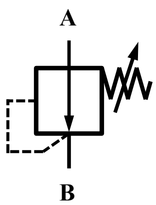
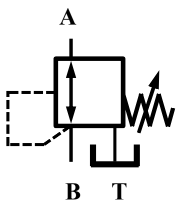
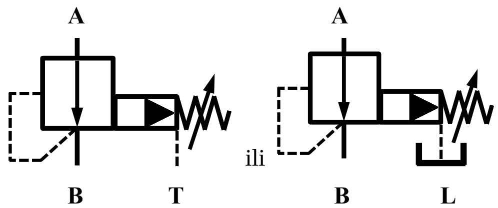
Razvijene su dve različite varijante upravljanja ovih ventila, prema čemu se oni dele na ventile sa eksternim ili internim upravljanjem. Redukcioni ventil je u normalnom položaju otvoren. Obično se postavlja u blizini aktuatora, u cilju ograničavanja njegove maksimalne radne sile ili obrtnog momenta (zavisno da li se radi o linearnom ili obrtnom aktuatoru), ali ponekad i radi zaštite od prekomernog pritiska i preopterećenja. U cilju poboljšanja stabilnosti regulacije pritiska (smanjenja pulzacija), često se pomeranje ventila usporava ugradnjom dodatnih odgovarajućih prigušnica.

Postoje dva osnovna tipa redukcionih ventila: dvograni i trograni. Dvograni redukcioni ventili predstavljaju osnovnu konstrukciju, sa jedinim zadatkom održavanja stalnog pritiska. Pritisak na izlaznom priključku (**A**) je u negativnoj povratnoj sprezi sa otvaranjem ventila (povećanje pritiska pojačava prigušno delovanje ventila). Ventil održava zadati pritisak tako što je rezultujuća sila tog pritiska na čelo radnog klipa ventila u ravnoteži sa silom podešenom na oprugi.

Za razliku od njih, trograni redukcioni ventil predstavlja kombinaciju redukcionog i sigurnosnog ventila – u slučaju prekoračenja maksimalne dozvoljene vrednosti pritiska, trograni ventil rasterećuje granu sistema koju štiti otvaranjem izlaznog priključka ka rezervoaru (**T**).

Tabela 6. Simboli ventila za umanjenje pritiska - redukcionih ventila.

Table 6. Symbols of pressure reducing valves.

	**Dvograni ventil za umanjenje pritiska (redukcioni ventil) sa podesivom oprugom i eksternim (spoljašnjim) upravljanjem.** *Ima dva priključka.
	**Dvograni ventil za umanjenje pritiska (redukcioni ventil) sa podesivom oprugom i internim (unutrašnjim) upravljanjem.** *Ima dva priključka, pa se označava kao “dvograni”.
	**Trograni jednostepeni redukcioni ventil sa tri priključka.** *Obzirom da ima tri glavna priključka ka različitim delovima hidrauličkog sistema, označava se kao “trograni”.
	**Dvostepeni posredno upravljani dvograni redukcioni ventil sa eksternim (spoljašnjim) rasterećenjem (drenažom).** *Fluid za hidrauličko upravljanje ventilom se odvodi u pomoćni (**L**) ili glavni rezervoar (**T**).

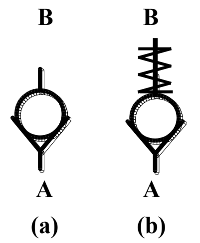
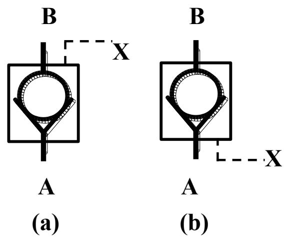
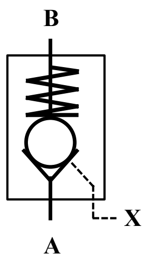
GRAFIČKI SIMBOLI NEPOVRATNIH HIDRAULIČKIH VENTILA

Nepovratni ili zaporni ventili dozvoljavaju protok radne tečnosti samo u jednom (predviđenom, dozvoljenom) smeru (**A** → **B**), a blokiraju u suprotnom (**A** ← **B**). Zatvarački elementi nepovratnih ventila mogu imati oblik kugle, konusa, tanjira (pečurke) ili čaure. Nepovratni ventili se konstruktivno izvode kao neopterećeni (bez opruge) ili opterećeni, koji poseduju elastičnu oprugu.

Razvijene su i konstrukcije nepovratnih ventila sa hidrauličkim blokiranjem ili deblokiranjem. Ventili sa hidrauličkim deblokiranjem normalno dozvoljavaju protok predviđenom smeru (**A** → **B**). Međutim, dovođenje upravljačkog fluida povišenog pritiska na upravljački priključak **X**, deblokira ventil omogućavajući protok u suprotnom smeru. Kopd nepovratnih ventila sa hidrauličkim blokiranjem, situacija je obrnuta.

Tabela 7. Simboli nepovratnih ventila.

Table 7. Symbols of check valves.

<table>
<tr><td>
</td><td>Nepovratni ventili. Postoje dva osnovna tipa običnih nepovratnih ventila:
(a) neopterećeni nepovratni ventili (bez opruge) i
(b) nepovratni ventili sa elastičnom oprugom (tzv. opterećeni ventili).</td></tr>
<tr><td>
</td><td>Upravljani nepovratni (blokirajući) ventili:
(a) upravljano blokiranja toka;
(b) upravljano deblokiranja toka.</td></tr>
<tr><td>
</td><td>Opterećeni (sa oprugom) upravljani nepovratni (blokirajući) ventil.</td></tr>
</table>

Hidraulički nepovratni ventili se najčešće konstruktivno izvode kao obični nepovratni ventili. Njihov jedini zadatak je sprečavanje povratnog strujanja (toka) radne hidrauličke tečnosti. Grafičke simboličke oznake ovih ventila su predstavljene u tabeli 7.

Postoje dva osnovna tipa običnih nepovratnih ventila:

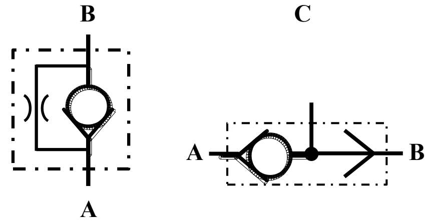
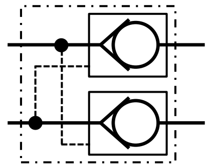
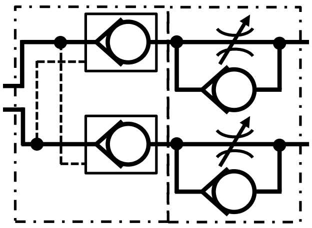
(a) neopterećeni nepovratni ventili (bez opruge) i

(b) nepovratni ventili, opremljeni elastičnom oprugom koja pritiska zatvarački element, zbog čega su nazvani opterećeni ventili.

Pored najjednostavnijih osnovnih konstrukcija, razvijene su i složenije izvedbe nepovratnih ventila. Osim osnovnog zadatka sprečavanja toka u neželjenom smeru, složeni multifunkcijski nepovratni ventili mogu obavljati i druge dodatne funkcije, kao što je na primer, prigušivanje protoka. Simboli nekih tipova iz ove podgrupe hidrauličkih nepovratnih ventila su prikazani u tabeli 8.

Tabela 8. Simboli složenih (kombinovanih) nepovratnih ventila.

Table 8. Symbols of complex (multifunction) check valves.

 (a) (b)	**(a) Nepovratno-prigušni ventil.** Pprigušuje protok u jednom smeru, a u suprotnom smeru protok je slobodan sa minimalnim gubitkom pritiska. Prigušenje se ne može menjati. **(b) Naizmenično-nepovratni ventil.** Izoluje dva alternativna dela (strujna kola) hidrauličkog sistema (**A** i **B**).
	**Dvostruki hidraulički aktivirani nepovratni ventil.**
	**Dvostruki podesivi nepovratno prigušni ventil sa dvostrukim hidraulički aktiviranim nepovratnim ventilom.**

GRAFIČKI SIMBOLI HIDRAULIČKIH VENTILA ZA PROTOK

Ventili za protok u hidrauličkom sistemu primarno služe za podešavanje protoka i/ili održavanje njegove konstantne vrednosti i/ili njegovo otvaranje ili potpuno prekidanje. Promena protoka najčešće se ostvaruje podešavanjem površine protočnog preseka radne hidrauličke tečnosti kroz ventil.

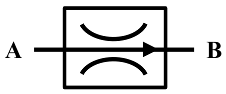
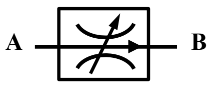
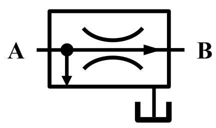
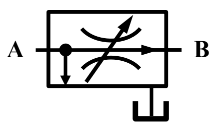
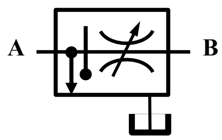
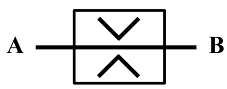
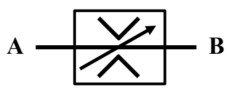
Prvu kategoriju ventila za protok predstavljaju prigušni elementi, odnosno hidraulički ventili opremljeni prigušnicama i blendama (dijafragmama) kao prigušnim elementima. U opštem slučaju, prigušnice imaju oblik uskih kanala, a dijafragme su oblika ploče sa uskim kružnim otvorom za proticanje radne tečnosti. Za razliku od prigušnica, lokalni hidraulički otpor dijafragmi u granicama radnog područja skoro ne zavisi od viskoznosti fluida (a time ni od njegove temperature). To je i razloga zbog koga se dijafragme koriste za merenje protoka radne tečnosti u cevima u koje su ugrađene. Principijelno, prigušne hidrauličke komponente se mogu podeliti na one sa fiksnim ili podesivim (varijabilnim) protokom.

Osnovnoj grupi prigušnih ventila pripadaju ventili sa ugrađenim prigušnicama i blendama, čiji su simboli zajedno sa kratkim opisima prikazani u tabeli 9. Ovo su ujedno i najjednostavnije konstrukcije prigušnih ventila, koji se često sreću u tehničkoj praksi.

Neki od njih omogućavaju promenu protočnog preseka prigušnih elemenata, a drugi ne, zavisno od namena i potreba hidrauličkih sistema ili njihovih ogranaka u koje su ventili ugrađeni. Naravno, promenom veličine površine "svetlog" poprečnog preseka kroz koji protiče radna tečnost unutar podesivog prigušnog ventila, menjaju se koeficijent lokalnog hidrauličkog otpora i pad pritiska tečnosti unutar ventila, što utiče i na odgovarajuću promenu protoka.

Tabela 9. Simboli osnovnih tipova prigušnih ventila.

Table 9. Symbols of basic types of throttle valves.

	**Prigušni ventil sa fiksnom prigušnicom.** Nije moguće podešavati veličinu protoka.
	**Prigušni ventil podesivog (varijabilnog) protoka.** Protok hidrauličke tečnosti se kod ovakvih ventila može menjati, prema želji rukovaoca, odnosno potrebama sistema.
	**Prigušni ventil stalnog (fiksnog) protoka sa drenažom i rasterećenjem (kompenzacijom) pritiska.** Ima priključak za rasterećenje pritiska, kroz koji se odvodi višak radne hidrauličke tečnosti u rezervoar. Varijacije pritiska tečnosti na ulaznom priključku ventila ne utiču na veličinu protoka.
	**Prigušni ventil podesivog (varijabilnog) protoka sa drenažom i kompenzacijom pritiska.** Može se menjati protok prema potrebama hidrauličkog sistema. Opremljen je priključkom za rasterećenje pritiska, kroz koji se odvodi višak hidrauličke tečnosti u rezervoar.
	**Prigušni ventil podesivog (varijabilnog) protoka sa drenažom i kompenzacijom pritiska i temperature.** Može se menjati protok prema potrebama hidrauličkog sistema. Opremljen je priključkom za rasterećenje pritiska, kroz koji se odvodi višak hidrauličke tečnosti u rezervoar.
	**Prigušni ventil sa fiksnom blendom.**
	**Prigušni ventil sa podesivom blendom.**

Grupa osnovnih prigušnih hidrauličkih ventila, čije su grafičke simboličke oznake prikazane u tabeli 9, dozvoljava protok radne tečnosti u oba smera. Međutim, to u nekim specifičnim situacijama nije preporučljivo, a nekada nije ni dozvoljeno. Stoga su razvijeni tzv. jednosmerni prigušni ventili, koji se još nazivaju i prigušno-nepovratni ventili. Kod ove grupe ventila, simboličkih oznaka prikazanih u tabeli 10, protok tečnosti se prigušuje u dozvoljenom smeru strujanja.

U drugom smeru, koji odgovara tzv. povratnom toku, ventili se automatski zatvaraju i time onemogućavaju protok radne hidrauličke tečnosti.

Tabela 10. Simboli prigušno–nepovratnih ventila.

Table 10. Symbols of basic types of throttle valves.

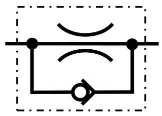
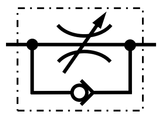
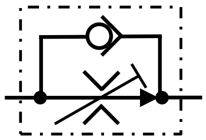
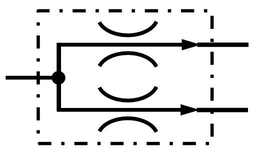
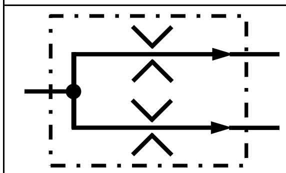
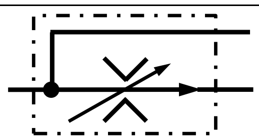
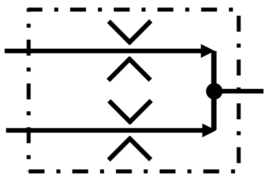
	**Jednosmerni prigušni (prigušno-nepovratni) ventil stalnog protoka hidrauličke tečnosti.** Protok je prigušen u jednom smeru, a u suprotnom je slobodan, sa zanemarljivim padom pritiska.
	**Jednosmerni prigušni (prigušno-nepovratni) ventil podesivog protoka hidrauličke tečnosti.** Protok je kontrolisan u jednom smeru, a u drugom je slobodan, sa zanemarljivim padom pritiska.
	**Jednosmerni protočni ventil sa podešavanjem protoka nezavisno od viskoznosti.**

Tabela 11. Simboli razdeljivača i sabirnika protoka.

Table 10. Symbols of flow dividers and flow collectors.

	**Razdeljivač protoka koji deli ulazni tok na dva izlazna toka jednakih protoka, viskozno zavisan.**
	**Razdeljivač protoka koji deli ulazni tok na dva izlazna toka jednakih protoka, viskozno nezavisan.**
	**Ventil sa tri priključka, koji deli ulazni protok na dva dela: izlazni tok podesivog protoka i drugi izlazni tok kome odgovara preostali deo protoka.**
	**Sabirnik protoka, viskozno nezavisan.**

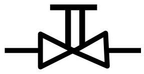
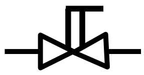
U savremenoj tehničkoj praksi često se sreću hidraulički sistemi, u okviru kojih jedna pumpa napaja dva ili vise aktuatora hidrauličkom tečnošću povišenog pritiska.

U ovakvim sistuacijama se obično primenjuju razdeljivači protoka različitih konstrukcija. Njihovi grafički simboli su prikazani u tabeli 11, zajedno sa simboličkom oznakom sabirnika protoka.

Veoma važnu ulogu i široku primenu u hidraulici nalaze i zatvarački ventili, čiji simboli su prikazanih u tabeli 12. Njihov osnovni zadatak je potpuno zatvaranje ili otvaranje protoka radne hidrauličke tečnosti kroz određeni deo hidrauličkog sistema.

Tabela 12. Simboli zatvarača protoka.

Table 10. Symbols of shut-off valves.

	Opšti simbol ventila zatvarača protoka.
	Zatvarački loptasti ventil 2/2.
	Zatvarački ventil sa sedištem.

ZAKLJUČAK

Opstanak i napredak savremene poljoprivredne tehnike suštinski su povezani sa širokom primenom elektronski kontrolisanih hidrauličkih sistema spregnutih sa mehaničkim elementima prenosa snage i upravljanja [12]. Ovaj rad predstavlja logičan nastavak prvog dela rada, pod nazivom „Hidraulički simboli - deo I: opšti simboli i oznake mernih instrumenata i indikatora“, i drugog dela istog rada sa naslovom „Hidraulički simboli - deo II: pumpe i izvršni organi“, posvećenog pripadajućoj tematici. Stoga je tekući treći deo rada posvećen prikazivanju i opisivanju hidrauličkih simbola računa tipova ventila, koji obavljaju niz operativnih zadataka vezanih za upravljanje sistemom. Simboli svih grupa hidrauličkih ventila, koje su u fokusu ovog rada, definisani su ISO industrijskim standardima.

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HYDRAULIC SYMBOLS – PART THREE: VALVES

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Abstract: Similar to human health, the importance of hydraulics sometimes becomes apparent only in her absence. Images and motives of agricultural workers from the past times and centuries can look attractive only on paintings of arts. In reality, it was a very hard and sometimes quite dangerous job.

The introduction of hydraulics in construction of modern farming machines, agriculture is less demanding for all farm workers, but also more efficient, which is of particular importance for providing enough food for the growing world during the 20^{-th} century. Achieving high efficiency, reliability and long service life of these systems requires sophisticated diagnostics and failure repairment, regular maintenance and careful use of each hydraulic system, and this is only possible with a good knowledge of the functional principles of all elements, their connections and the whole system. However, modern hydraulic systems of agricultural machines are often very complicated, and the construction of their components is too complex for detailed graphic representation within the whole corresponding hydraulic installation. Therefore, instead of detailed representation of the components, schematic diagrams are used. This manuscript represents a logical continuation of the first and second parts of the paper, devoted to the general symbols, labels of measuring instruments and indicators (part one), as well as pumps and actuators (part two). The third) part of the paper presents the hydraulic symbols of the system control elements - hydraulic valves. The graphical symbols of these components are defined by ISO standards.

Key words: *hydraulics, system, symbol, scheme, hydraulic control element, valve, directional control valve*

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UTICAJI PROCESA REINŽINJERINGA ELEKTROOPREME TRAKTORA NA KONKURENTSKU PREDNOST

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Sažetak: Centralno mesto i najvažniju ulogu, izuzimajući nestabilnosti i pojave kriznog poslovanja koji dolaze izvan preduzeća, imaju procesi u preduzeću. Kako bi se zadržala pozicija na konkurentnom tržištu, neophodno je definisati i inplementirati poslovne procese reinženjeringa u preduzeću. Obzirom da savremene tehnologije imaju nezamenjivu poziciju u svim procesima poslovanja potrebno je da se proizvođači prilagode novonastalim situacijama. U uslovima savremenog poslovanja, proizvođači traktora i motora treba da obezbede alternativne kombinacije zamene postojeće elektroopreme traktora odgovarajućom, koja podržava diferentne aplikacije upotrebom istih ili novih senzora. To podrazumeva opsežna ispitivanja uzoraka elektrooprema pre ugradnje, po propisanim procedurama i metodologiji. Na osnovu dobijenih rezultata i definisanih tehničko-funkcionalnih karakteristika formira se ocena upotrebnog kvaliteta ispitivanog uzorka i sistema u celini. Kako poslovni procesi reinženjeringa nalažu podprocese i nove procedure, sprovode se neophodna laboratorijska ispitivanja i eksploatacijona istraživanja. Preduzeća koja svojim procesima na najbolji način upotrebljavaju svoje resurse ostvarujući konkurentnu prednost koja rezultira superiornim kreiranjem vrednosti. Dobijeni rezultati vode prema sticanju dodatnih vrednosti, odnosno projektovanju novog ili redizajniranog proizvoda sa savremenom elektroopremom i modernim dizajnom. Napredne tehnologije kod elektroopreme traktora imaju za cilj da doprinesu ukupnom kvalitetu traktora a rukovaocu traktora omoguće efikasnost, komfornost, sigurnost u radu i bezbedno kretanje u saobraćaju.

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Projekat*: Istraživenje i primena naprednih tehnologija i sistema za poboljšanje ekoloških, energetskih i bezbedonosnih karakteristika domaćih poljoprivrednih traktora radi povećenja konkurentnosti u EU i drugim zahtevima tržišta*. Broj TR-35039. Ministarstvo prosvete, nauke i tehnološkog razvoja , Republika Srbija.

Ovaj rad daje deo eksploatacionih istraživanja postojeće elektroopreme i laboratorijskih ispitivanja provere funkcionalnosti savremenog stuba upravljača sa pripadajućim senzorom.

Cilj ovih ispitivanja je traženje altrenativnh komponenti elektroopreme. Doprinos ovakvog načina ispitivanja je nesumljiv jer obezbeđuje kvalitet poljoprivrednih traktora i povećava konkurenstsku prednost. Istovremeno omogućava proizvođačima elektroopreme da poboljšavaju karakteristike svojih proizvoda.

Ključne reči: *Traktor, elektrooöprema, poslovni procesi, istraživanja, novi proizvod.*

UVOD

Cilj većine poslovnih strategija je da preduzeće ostvari održivu konkurentnu prednost. Identifikovana su dva osnovna tipa konkurentne prednosti: prednost cene i prednost razlikovanja u odnosu na konkurente [25]. Ako je preduzeće sposobno da ponudi prednosti kupcima koje prevazilaze prednosti konkurentnih proizvoda (funkcionalnost, pouzdanost, održavanje u garantnom roku i nakon isporuke, bolji dizajn), onda je to prednost razlikovanja [24]. Prednosti cene i razlikovanja u odnosu na konkurente donose sigurno pozicioniranje i povećava udeo na tržištu [2]. Svakako od velikog su značaj i resursi za sticanje konkurentske prednosti. Kompanija koja svojim procesima na najbolji način iskorišćava svoje resurse ostvarujući konkurentnu prednost koja rezultira superiornim kreiranjem vrednosti. Veoma bitnu i ključnu poziciju imaju procesi u preduzeću. Razumevanje menadžmenta za mogućnosti postizanja cilja pomoću procesa, organizovanje i upravljanje procesima, su veoma značajni za konkurentnost preduzeća na tržištu [26]. Pristupi teoretičara u sagledavanju uloge i uticaja procesa na konkurentnost preduzeća je različita. Vodeću konkurentsku prednost velikih kompanija ogleda se u shvatanju i razumevanju da se ona ne može ostvariti jednom posebnom funkcijom u preduzeću [28]. Potreno je da menadžment preduzeća nastoji i udovolji potrebama potrošača, gledajući na krajnjeg korisnika kao na svoj najvažniji zadatak.

Model baznog procesa treba da ojača strategiju organizacije time što se strateška pitanja stavljaju u fokus [3]. Dakle promena strategije u velikoj meri je zavisna od procesa u organizaciji, a procesi zavise od ukupnog stanja okruženja preduzeća. Procesi u proizvodnom preduzeću pretvaraju unutrašnje aktivnosti u materijalne i finansijske resurse [4]. Istovremeno su velika i nezamenljiva koristi za potrošače odnosno krajnje korisnike jer su najbolji stalni marketing. U široj stručnoj literatuti definicije procesa od strane autora koji stvaranje vrednosti za potrođača i organizaciju vide kroz strategiju promena na procesima. Postoje četiri osnovne komponente preduzetničkog procesa: razvijanje biznis ideje, obezbeđivanje resursa, implementacija kroz uspostavljanje biznisa, opstanak i rast [16]. Preduzetnički proces zasnovan na inovacijama može se posmatrati kroz četiri osnovne aktivnosti: inovacije, aktivirajuće događaje, implementaciju i rast [8]. Procesi se koriste organizacionim resursima kako bi obezbedili i definisali rezultate. Preduzetnički proces može da definiše jednu ili više aktivnosti uzimajući unutrašnjost objekta, dodavanje nove vrednosti, obezbeđenje internog ili eksternog potrošača sa rezultatom [33].

Procesi u kompaniji su načini da logična organizacija ljudi, materijala, energije, alata i procedura bude cilj opisa radnih aktivnosti za proizvodnju nekih specifičnih rezultata [20]. Poslovni procesi mogu se posmatrati i kao serija lančanih aktivnosti [28]. Istovremeno to je lanac aktivnosti koji u povratnim tokovima stvara vrednost potrošaču kroz projekciju inoviranog ili novog proizvoda [34].

Za inoviranje postojećeg i projektovanje novo proizvoda potrebna je inplementacija poslovnih procesa reinženjeringa što podrazumeva strategijsko planiranje koje respektuje promene u preduzeću uvođenjem koncepta kontigencije [10]. Da bi se koncept kontigencije mogao primeniti, potrebno je da se većina elemenata u preduzeću jednako odnosi prema okruženju, strategiji i poslovnim procesima [11]. Kada su sistemi planiranja kompatibilni sa drugim sistemima u preduzeću, uspostavljena je i kontigencija [32]. Primena ideje kontigencije i na druge faze procese upravljanja dovodi do transformacije strategijskog planiranja [36]. To je izraz potrebe za prilagođavanjem preduzeća izazovima stalno menjajućeg okruženja. Počev od 1970-tih godina okruženje postaje složeno i visoko regulisano, tehnološki razvoj ubrzan, tržišta segmentirana i izložena sve većem pritisku međunarodnih konkurenata [24].

Pistup poslovnim procesima reinženjeringa predstavlja model ponašanja zasnovan na principu ukupnog poslovanja preduzeća i baziran je na koleraciji između ciljeva i strategije [13]. Preduzeća može artikulisati samo ukoliko postoji čvrsta veza između ciljeva i strategije [27]. U određivanju ciljeva pored ekonomskog aspekta moraju se imati u vidu i pozicija i moć pojedinih interesnih grupa. Ukoliko se pođe od predpostavki da okruženje čine eksterni elementi koji utiču na ponašanja preduzeća, dolazi se do zaključka da se okruženje ne može kontrolisati ali da se na njega može uticati. Posledično, jedan aspekt planiranog poslovanja mora biti predviđanje okruženja kako bi se preduzeće na vreme pripremilo za njegove uticaje [15]. Način na koji se formuliše strategija je model koji se bazira na tehničko-tehnološkim predpostavkama, efikasnost preduzeća određena je strukturom tržišta, stanjem u razvoju kooperacije, specijalizacije, raspoloživošću izvora finansiranja kao i razvijenošću sistema upravljanja u preduzeću i privredi [23]. U savremenim uslovima poslovanja neophodno je preduzeti određene korake u realizaciji različitih inicijativa. To naravno podrazumeva promene poslovne strategije, strukture i radne prakse. Ove promene su potrebne kako bi preduzeće ostalo konkurentno u promenljivim tržišnim uslovima poslovanja [14].

Tranzicioni period je doveo do gašenja mnogih preduzeća čija je delatnost bila proizvodnog karaktera. Sve to je rezultiralo probleme kod drugih preduzeća koja su morala da traže alternativne dobavljače kako ne bi umanjili odnosno obustavili proizvodnju svog proizvodnog programa [22]. Za stabilno i nesmetano funkcionisanje proizvodnje traktora neophodno je imati stalne i sigurne dobavljače elektroopreme [21]. To se naravno odnosi na odgovarajuće standarde počevši od sirovine odnosno materijala pa do namenske funkcije za svoju svrsishodnost [1].

Instrument tabla traktora sa pripadajućom elektroopremom u odnosnom slučaju je direktno izložena visokim i niskim temperaturama kao i atmosferskim padavinama čiji uticaj na ispravnost i kontinuitet u rada traktora nije zanemarljiv. Zaptivenost elektroopreme koja se ugrađuje na traktor odnosno instrument tablu je značajna i rešenjem tog problema direktno ima uticaja na ukupan kvalitet traktora [12].

Intenzivan razvoj savremene tehnike poljoprivredne mehanizacije doprineo je da proizvođači sve više ulažu u ispitnu mernu opremu kao i potrebnu prateću elektroopremu [32]. Ovo sa jedne strane omogućava proizvođačima da precizno i brzo kontrolišu sve najbitnije karakteristike traktora.

Kupcima odnosno krajnjim korisnicima da imaju tačnu informaciju koja uz to ima i dimenziju savremenosti ugrađenih tehnologija. Zadovoljavanje zahteva korisnika u današnjem vremenu podrazumeva obezbeđenje objektivnih pokazatelja kvaliteta traktora za sve veći broj parametara. Ovaj rad daje pregled laboratorijskih ispitivanja provere funkcionalnosti komandne table stuba upravljača sa pripadajućim senzorima za primenu kod traktora. Cilj ovih ispitivanja je iznalaženje novih mogućih altrenativh komponenti elektroopreme za buduću ugradnju na traktore [29]. Dobijeni rezultati laboratorijskih ispitivanja prikazani su tabelarno. Ispitivanja pružaju objektivne informacije o kvalitetu motora i traktora, njegovih sklopova i delova, u realnim uslovima rada odnosno o radnim opterećenjima kao i uslovima okoline [30]. Istovremeno poseduju objektivni karakter koji je zasnovan na neposrednom ili posrednom merenju određenih mernih veličina. Zbog ovih osnovnih obeležija ispitivanja imaju poseban značaj u opštem informacionom sistemu proizvođača i korisnika. Doprinos ovakvog načina ispitivanja je nesumljiv jer obezbeđuje kvalitet poljoprivrednih traktora i omogućava proizvođačima elektroopreme da poboljšavaju karakteristike svojih proizvoda.

MATERIJAL I METODE RADA

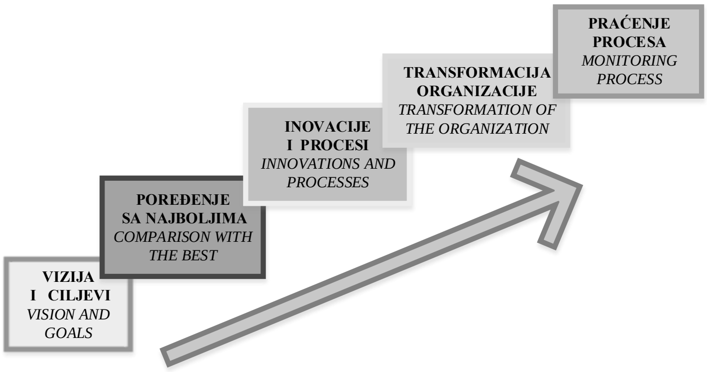
Na traktore IMR-a ugrađuje se standardna elektrooprema već dugi niz godina i preduzeće IMR se suočava sa problemom nabavke ovih delova. Situacija je neizvesna jer se elektroinstalacija traktora svakodnevno prilagođava nekim novim komponentama što samo otežava posao i produžava vreme proizvodnje. Pored toga, neki delovi elektroopreme su deficitarni, bez sertifikata i nezadovoljavajućeg kvaliteta. Zbog navedenog potrebno je edukovati zaposlene kroz treninge kao i njihovo stalno usavršavanje u smislu samostalnog odlučivanja u pojedinim sitacijama [30].

Da bi proizvodi, motori i traktori, bili na zadovoljavajućem nivou, potrebno je da sva elektrooprema koja je njegov sastavni deo bude jasno definisana propisanim standardima. Kako bi se odabrao dobavljač elektroopreme potrebno je strogo standardizovati sve relevantne kriterijume kao i pridržavati se zadatog. Naravno, to takođe podrazmeva i fleksibilnost u izuzetnim situacijama i iziskuje potrebnu adaptabilnost kada je u pitanju zahtev kupca [18].

Do sada se nije pratilo i istraživalo tržište nije pridavao značaj zahtevima korisnika, a u osnovi to je polazna linija uspeha preduzeća. Zato je neophodan reinžinjering kako bi se rešili i prevazišli postojeći probleni i unapredila profitabilnost preduzeća. Inplementacijom i realizacijom poslovnih procesa reinženjeringa u preduzeću, koji su prikazani na slici 1., može se postići i unaprediti željena konkurentska prednost preduzeća [19].

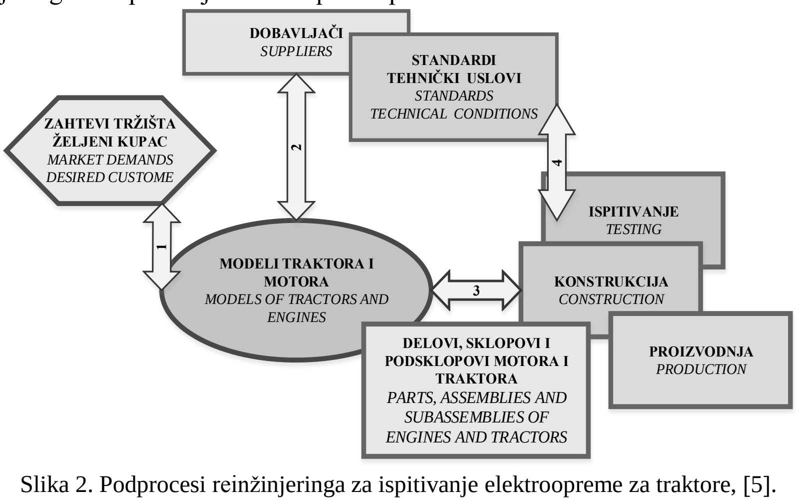
Slika 1. definiše pet poslovnih tipova procesa reinžinjeringa. *Prvi poslovni* proces reinžinjeringa podrazumeva realizaciju zahteva korisnika odnosno tržišta [28]. To je praćenje tržišta pomoću zadatih varijabli i faktora koji ga definišu i naravno proizvodnja za željenog klupca.

Drugi poslovni proces reinžinjeringa se odnosi na poređenje sa najboljim proizvođačem traktora što podrazumeva sve performanse koje karakterišu izabrani model traktora za poređenje.
Treći poslovni proces reinžinjeringa obuhvata inovacije i odnosi se na konstrukciju, projektovanje, ispitivanje i proizvodnju.



Slika. 1 Poslovni procesi reinžinjeringa u preduzeću, [5].
Figure 1. Business processes of reengineering in the enterprise, [5].

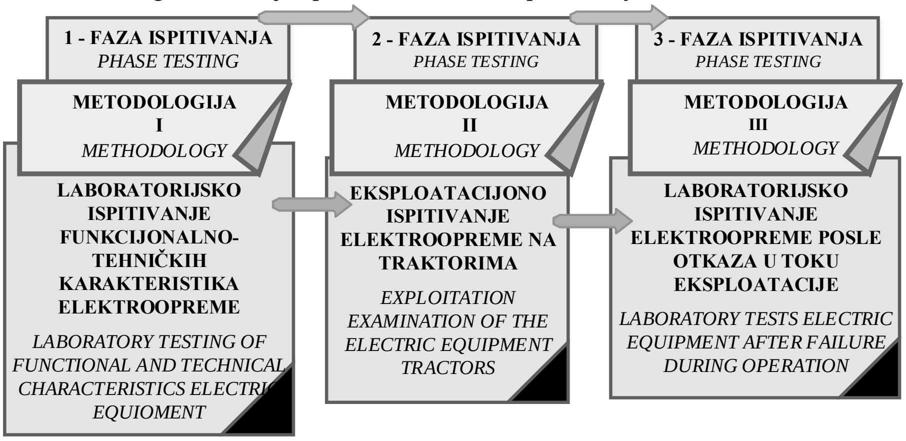
To istovremeno podrazumeva redizajniranje procesa na osnovu koji će se definisati i inplementirati novi potrebni procesi, poboljšavajući postojeće procese. Bitno je naglasiti da se u ovom poslovnom procesu uključuju zaposleni kao i nove planirane tehnologije, kako bi se značajno poboljšale performanse u poslovnim jedinicama preduzeća.
Četvrti poslovni proces reinžinjeringa preduzeća, kao organizacione celine, odnosno sistema, podrazumeva transformaciju u organizaciji poslovanja, menjajući strukturu i strategiju. Na taj način se podržavaju novi procesi. *Peti poslovni proces* je merenje rezultata reinžinjeringa i krajnjih efekata projekta. Na slici 2. prikazani su podprocesi reinženjeringa za ispitivanje elektroopreme potrebne za traktore.



Slika 2. Podprocesi reinžinjeringa za ispitivanje elektroopreme za traktore, [5].
Figure 2. Sub-processes of reengineering for testing electrical equipment for tractors, [5].

Obzirom da je dosadašnja elektrooprema traktora veoma zastarela jer su pokazivači fukcionalnih parametara rada motora mehaničkog karaktera, važan korak je uvođenje elektroopreme koja je u osnovi električna. To podrazumeva uvođenje i upotrebu nove tehnologija sa savremenim senzorima. Ova neizostavna promena je neminovna obzirom da nema dobavljača za mehaničke pokazivače funkcionalnih parametara motora a istovremeno je potrebno pratiti konkurente na tržištu. Reinžinjeringom su definisani inovacioni procesi i podprocesi prikazani na slici 2. Osnovna karakteristika je kontinualno praćenje i međusobno funkcinisanje svih poslovnih aktivnosti kako bi se poboljšali postojeći poslovni procesi i unapredio kvalitet proizvod.

Implementacijom poslovnih procesa reinžinjeringa sprovedena su ogledno-eksploatacijona istraživanja, koja su imala za cilj da provere delove elektroopreme na traktorima bez kabine sa aspekta zaptivenosti, pre i posle ugradnje na traktore. Obzirom da su traktori bez kabine izloženi direktnim i svakodnevnim atmosferskim uticajima, ovakvim istraživanjem definisao bi se uzrok otkaza pojedinih delova i sklopova ugrađene elektroopreme. Istovremeno cilj je bio da se dobije transparentan prikaz učestalosti otkaza elektroopreme u celini, tokom vremena rada traktora u realnim uslovima. Plan ovog istraživanja sproveden u tri faze, prikazan je na slici 3.



Slika 3. Plan istraživanja uzoraka elektroopreme kod traktora bez kabine, [6].
Figure 3. Research plan for samples of electrical equipment in tractors without cab, [6].

Istraživanje je obuhvatilo laboratorijska i ogledno-eksplatacijona ispitivanja a odvijalo se u tri faze. Prva faza odnosila se na laboratorijsko ispitivanje tehničko-funkcionalnih karakteristika svih uzoraka elektroopreme koja je ugrađena na tri uzorka traktora modela traktora R-47 bez kabine. Nakon toga, usledila je druga faza, koja je obuhvatila ugradnju elektroopreme na traktore i ogledno-eksploatacijono ispitivanje tri odabrana uzorka traktora. U toku eksploatacionih ispitivanja traktora, kontinualno se pratio rad ugrađene elektroopreme koja je izložena uticajima visokih i niskih temperatura, povećanoj vlažnosti kao i atmosferskim padavinama: kiši i snegu. Na osnovu podataka o radu ugrađene elektroopreme u toku eksploatacije, prikazan je dijagram otkaza elektroopreme sa najvećim procentom učešća u otkazima.

Treća faza ovog ispitivanja odnosila se na laboratorijsko ispitivanje svih uzoraka elektroopreme, sa najvećim procentom otkaza u toku eksploatacijonog perioda kod tri uzorka traktora. U ovom slučaju najveći broj otkaza elektroopreme odnosi se na kontakt brave. Zatim je usledila kontrola dimenzija pripadajućih delova kontakt brave kao i uporedni tabelarni prikaz gabaritnih mera za podlošku.

U okviru ovog radu analizirani su uzroci otkaza elektroopreme traktora sa aspekta zaptivenosti koji su doveli do neispravnosti u rada traktora. Rezultati ovog ogledno–eksploatacijonog istraživanja su korisni za proizvođača traktora, kako bi se napavio adekvatan odabir dobavljača elektroopreme. Istovremeno ovakav metod ispitivanja elektroopreme značajno povećava i održava ukupan kvalitet traktora, kao i zadovoljstvo krajnjeg korisnika odnosno rukovaoca traktora.

Shodno napred navedenom, prema inplementiranim poslovnim procesima reinženjeringa usledio je odabir novog dobavljača i ispitivanja nove elektroopreme. U ovom slučaju to se odnosi na stub upravljača proizvođača *"Cobe"*-Italija, za nove buduće modele traktora. Na osnovu raspoložive dokumentacije i tehničkih uslova raspoloživih u Institutu IMR, obavljena su laboratorijska ispitivanja odgovarajućeg senzora i pokaznog instrumenta na komandnoj tabli stuba upravljača, radi provere funkcionalnosti. Laboratorijska ispitivanja su obuhvatila ispitivanje tačnosti pokaznog instrumenta za merenje temperature, pritiska vazduha i ulja i broj obrtaja motora i odgovarajućeg senzora. U ovom radu biće dat primer ispitivanja instrument za merenje pritiska ulja i pripadajućeg senzora. Rezultati biće tebelarno prikazani u cilju provere funkcionalnosti komandne table stuba upravljača i unapređenja kvaliteta traktora.

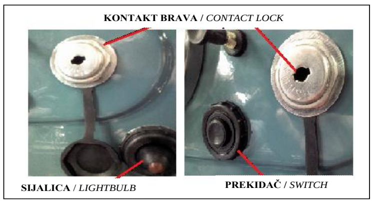
Sprovedena ogledno-eksploatacijonog istraživanja su obavljena na tri uzorka traktora bez kabine, modela Rakovica R47 slika 4. Ovaj model traktora ima ugrađenu metalnu instrument tablu datu na slici 5. U otvore instrument table postavlja se neophodna i propisana elektrooprema koja podrazumeva signalne sijalice, prekidače i kontakt brave.

Slika 4. Poljoprivredni traktor bez kabine model Rakovica R47, [7].
Figure 4. Agricultural tractor without cabin model Rakovica R47, [7].

Slika 5. Instrument tabla modela traktora R47 bez kabine, [7].
Figure 5. Instrument panel of the tractor model R47 without cab, [7].

Kako je ovaj model traktora bez kabine, od velikog značaja za kvalitet je uticaj vemenskih uslova koji podrazumevaju atmosfreske padavine kišu i sneg. Za ugradnju svih delova elektroopreme na instrument tabl potrebna je odgovarajuća plastična podloška zbog neophodne zaptivenosti radi umanjenja uticaja vlage i atmosferskih padavina odnosno eliminaciju mogućeg kvara u elektroinstalaciji traktora.

Na slici 6. prikazan je deo metalne instrument table kod modela traktora R-47 bez kabine sa ugrađenim elementima elektroopreme: signalna sijalica, prekidač i kontakt brava. Obzirom da je kontakt brava imala procentualno najviše otkaza, izvršena su laboratorijska ispitivanja koja su podrazumevala merenja plastične podloške pre i posle ugradnje na ispitivane uzorke traktora i sprovedenih ogledno-eksploatacijonog istraživanja pomenutih uzoraka. Na slici 7. prikazani su sastavni delovi kontat brave za traktorsku primenu i naznačena je plastična podloška koja je odgovorna za neophodnu zaptivenost na metalnoj instrument tabli.



Slika 6. Pozicije kontakt brave na instrument tabli i njeni sastavni delovi, [7]
Figure 6. Positions the ignition switch on the instrument panel and its component parts,[7]

Slika 7. Sastavni delovi kontakt brave [7]
Figure 7. Components of the contact locks,[7]

Razvoj savremene tehnike poljoprivredne mehanizacije doprineo je da proizvođači sve više ulažu u ispitnu mernu opremu što omogućava precizno i brzo kontrolisanje karakteristika traktora i motora. Istovremeno krajnjim korisnicima omogućena kvalitetniji i svremen proizvod.

Zadovoljavanje zahteva korisnika u današnjem vremenu podrazumeva obezbeđenje objektivnih pokazatelja kvaliteta traktora za sve veći broj parametara. Da bi se to postiglo potrebno je raspolagati odgovarajućom ispitnom opremom koja je u stanju da omogući brza, efikasna i precizna ispitivanja i obuhvati merenja velikog broja različitih fizičkih veličina. Važan segment je formiranje odgovrajućih radnih uslova, zašto je takođe potrebna odgovarajuća oprema.

Poslovni procesi reinženjeriga podrazumevaju inoviranje i upotrebu nove merne opreme koja će unaprediti kvalitet proizvoda a istovremeno povećati konkurentsku prednost preduzeća. Menadžment preduzeća odlučio se za moderan dizajn traktora bez kabine za koji je bio neophodan novi savremen stuba upravljača.

Na osnovu inplementiranih procesa reinženjeringa nabavljen je stub upravljača za traktorsku primenu od proizvođača ″Cobe″-Italija. Stub upravljača se sastoji od savremene komandne table, prikazanoj na slici 8. i pripadajućih senzora shodno nameni.

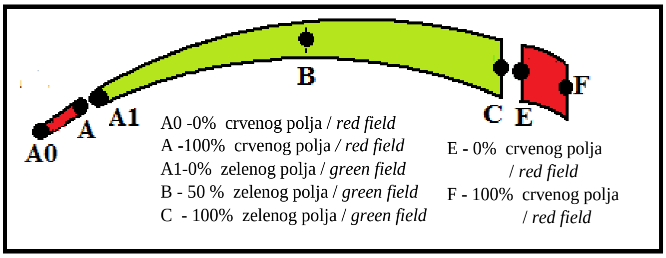
Slika 8. Komandna tabla stuba upravljača proizvođača *"Cobe"*, Italija, [6].
Figure 8. Dashboard control panel of manufacturer "Cobe", Italy, [6].

U radu je prikazan postupak laboratorijskih ispitivanja provere funkcionalnosti komandne table stuba upravljača sa pripadajućim senzorima za traktorsku primenu.
Cilj ovih uspitivanja je iznalaženje novih altrenativh komponenti elektroopreme za buduću ugradnju na traktore.

Usledila je provera funkcionalnosti komandne table stuba upravljača proizvođača ″Cobe″-Italija, prikazanog na slici 8. i pripadajućih uzoraka senzora za merenje pritiska ulja oznake /VEGLIA/0-12 bar/104-02, za primenu kod traktora.
Za ovo ispitivanje je korišćena laboratorijska baždarena merna opreme:

- uređaj za ispitivanje pritiska ulja "Amsler" tip 25,
- instrument za očitavanje temperature "Voltchraft 304" sa sondom K-tip.

Na osnovu raspoložive dokumentacije i tehničkih uslova obavljena su sledaća laboratorijska ispitivanja adekvatnog i odgovarajućeg pokazivanja senzora i pokaznog instrumenta na komandnoj tabli stuba upravljača. Kako bi prikaz obavljenog merenja pristiska ulja bio tačan, merna skala pokaznog instrumenta za merenje pritiska ulja na stubu upravljača data je na slici 9. Merna skala je prikazana sa odgovarajućom podelom i repernim tačkama na podeonoj skali.

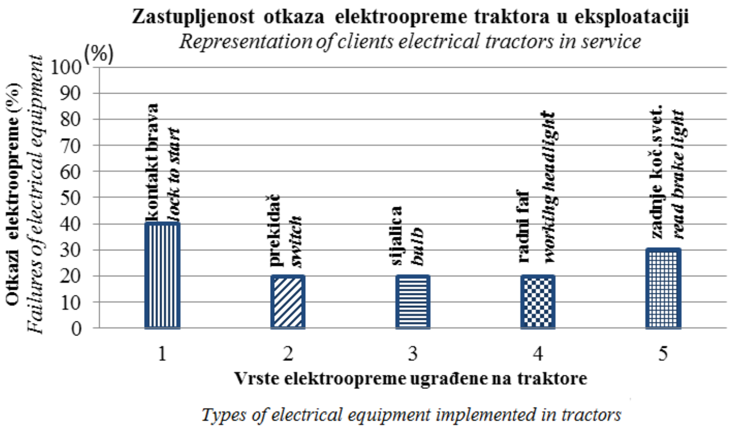


Slika 9. Pokazna skala pritiska ulja kod stuba upravljača proizvođača "Cobe"- Italija, [6].
Figure 9. Oil pressure display at the steering column of the manufacturer "Cobe"- Italy, [6].

Ispitivanje je obavljeno pri uslovima laganog hlađenja predhodno zagrejanog ulja u uslovima simuliranja termičkog kupatila kada je ostvaren dekrement od 1° na 45 sekundi u proseku. Rezulteti su prikazani tabelarno. Početna otpornost senzora iznosila je R=2,52 (kΩ) pri temperatura ambijenta Ta=22(°C).

REZULTATI ISTRAŽIVANJA I DISKUSIJA

Sprovedena ogledno-eksploataciona istraživanja su obavljena na tri uzorka traktora bez kabine, model Rakovica R47. Rezultati o procentualnom učešću otkaza elektroopreme su prikazani dijagramom (slika 10.). Sa datog dijagrama se vidi da od ugrađene elektroopreme na metalnoj instrument tablai procentualno najviše otkaza ima kontakt brava. Plastična podloška koja ostvaruje zaptivenost kod ugradnje kontat brave, sprečava prodor atmosferskih padavina kao i uticaj vlage, odgovorna je za ukupan kvalitet traktor.



Slika 10. Otkazi elektroopreme traktora R47 u toku eksploatacionog ispitivanja, [7].
Figure 10. Electrical faults of the tractor R47 during the exploitation test, [7].

U tabeli 1. date su kontrolisane gabaritne dimenzije gde se može videti nastala promena debljine plastične podloške, kao posledica izlaganja visokim i niskim temperaturama tokom eksploatacijonog rada. Važnost dobrog prijanjanja tela kontakt brave na instrument tablu je od značaja, jer se na taj način sprečava slivanje vode na kontakte same kontakt brave kao i druge delove elektroinstalacije traktora ispod instrument table.

Tabela 1. Izmerene vrednosti podloški kontakt brave pre i posle upotrebe na traktoru, [7].
Tabela 1. Measured values of the shaft contact pad before and after use on the tractor,[7].

Plastična podloška kontakt brave / *plastic the washer the contact lock*				
Kontrolisane dimenzije pre eksploatacije Controlled dimensions before exploitation	*Kontrolisane dimenzije posle eksploatacije Controlled dimensions after exploitation Uzorak / Simple*			
	1	*2*	*3*	*4*
38	*38*	*38*	*38*	*38*
ϕ26,2	*ϕ26,2*	*ϕ26,2*	*ϕ26,2*	*ϕ26,2*
0,5	***0,43***	***0,44***	***0,43***	***0,45***

Izmerene vrednosti kontrolisanih dimenzije četiri uzorka plastičnih podloški, pre ugradnje na traktore, bile su identične. U eksploatacionom periodu uzorci su bili izloženosti atmosferskih uticaja visokih i niskih temeperatura, usled čega je došlo do promene gabaritnih mera, što je uslovilo trajnu deformaciju plastičnih podloški. Nastala deformacija kod plastične podloške kontakt brave, dovodi do slabe zaptivenosti i velikog uticaja atmosferskih uslova.

U skladu sa zadatom metodologijom u trećoj fazi istraživanja, prvo je usledilo merenje otpornosti kontakata sva četiri uzoraka kontakt brave u laboratorijskim uslovima. U tabeli 2. dat je prikaz izmerenih vrednosti napona na kontaktima kontakt brave kao i jačina struje kroz kontakte brave.

Na osnovu prikazanih vrednosti napona i struje u tabeli 2. može se zaključiti da je pad napona na kontaktima kontakt brava u propisanim granice, definisanih prema proizvođaču *Perkins.* Atmosferski uticaji nisu direktno oštetili kontakte kontakt brave.

Tabela 2. Izmerene vrednosti napona i jačina struje kontakt brave traktora, [7].

Table 2. Measured voltage values and current strength of the tractor locking contact, [7].

Položaj ključa kontakt brave / Key lock contact position			*Napon/ Voltage*				*Jačina struje kontakt brave I (A)*
			Akumulator Battery U1 (V)	*Predgrejač Preheater U2 (V)*	*Kontakti / Contact 50 - 15/54 U3 (mV)*	*Kontakti / Contact 19 - 15/54 U4 (mV)*	*Current stren. contact lock I (A)*
Uzorak / simple	*1*	*S*	*12,2*	*-*	*115*	*-*	*41,6*
		H	*12,43*	*12,03*	*-*	*51*	*13*
		HS	*12,1*	*11,04*	*160*	*130*	*55,8*
	2	*S*	*12,25*	*-*	*110*	*-*	*40*
		H	*12,5*	*12,10*	*-*	*43*	*13*
		HS	*12,1*	*11,05*	*165*	*130*	*53,3*
	3	*S*	*12,05*	*-*	*150*	*-*	*48*
		H	*12,4*	*12,03*	*-*	*40,5*	*12,8*
		HS	*12,03*	*11,95*	*165*	*135*	*56,6*
	4	*S*	*12,05*	*-*	*145*	*-*	*44,1*
		H	*12,4*	*11,95*	*-*	*48*	*12,8*
		HS	*12,85*	*10,75*	*165*	*140*	*52,5*

Laboratorijsko ispitivanje je nastavljeno demontažom svih tela uzoraka kontakt brave. Vizuelnom metodom konstatovan je početak procesa patinizacije sastavnih delova uzoraka kontakt brave. Zatim su usledila laboratorijska kontrolna merenja sastavnih delova kontakt brave, kako bi se utvrdile moguće promene gabaritnih mera posle izlaganja atmosferskim uticajima. Izmerene vrednosti uporedile su se sa vrednostima izmerenim pre ugradnje na traktore. Konstatovana je promena gabaritne mere plastične podloške, koja služi za čvrsto prijanjanje kontakt brave na instrument tablu traktora.

Elektrooprema koja se ugrađuje na instrument tablu traktora, kapotažu i blatobrane, postavlja se pomoću odgovarajućih plastičnih podloški, kako bi se obezbedila potrebna zaptivenost. U toku dužeg vremenskog perioda izloženost atmosferskim uticajima visokih i niskih temeperatuta, plastične podloške se deformišu i na taj način se dovodi u pitanje zaptivenost elektroopreme odnosno gubi se namenska funkcija istih. Direktna promena gabaritnih mera plastične podloške omogućava dotok vode kroz otvore na pozicijama za ugradnju. Sve to prouzrokuje oksidaciju kontakata, izazvanu atmosferskim uticajima, čime se sprečava stabilno napajanje potrebno za startovanje motora, pokazne instrumente i signalizaciju. Istovremeno može doći i do kratakg spoja na elektroinstalaciji traktora i izazavati veliku matrijalnu štetu.

Analizom ogledno-eksploatacionog ispitivanja, koje je sprovedeno na tri uzorka IMR modela traktora R47 bez kabine, mogu se doneti zaključci:

- Uticaji atmosferskih padavina: kiša i sneg su nepovoljni za konkretnu posebno izabranu elektroopremu ugrađenu na traktore bez kabine.
- Odnosni uzorci kao i rezultati ispitivanja su prosleđeni dobavljačima sa sugestijama mogućih rešenja kako bi povećao kvalitet istih i time postigao zadovaoljavajući nivo. Ukazano je na poboljšanje procesne i laboratorijske kontrole i provere.
- Značaj sprovedenog ogledno-eksploatacionog istraživanja je u očuvanju i održivosti kvaliteta elaktroopreme koja se ugrađuje na traktore čime se štiti ukupan kvalitet traktora.
- Korisnicima traktora na ovaj način se obezbeđuje funkcionalnost, tačnost, operativnost, trajnost i sigurnost u obavljanju namenskih poslova.

Obzirom da je prepoznat problem otkaza elektroopreme kod traktora kao i njegove posledice na ukupan kvalitet taraktora, menadžment preduzeća je doneo strategiju koja vodi ka viziji odnosno ka novom i inoviranom proizvodu. Inplementacijom poslovnih procesa reinžinjeringa definisane su aktivnosti kako bi preduzeće zadržalo svoju poziciju na tržištu i postiglo veću konkurentsku prednost. Početni proces u lancu promena je istraživanje tržišta i praćenje zahteva kupaca. Sledeći proces je usklјađivanje zahteva sa elektroopremom raznih dobavljača.

Sva elektrooprema mora biti ispitana, verifikovana od starne proizvođača kao i od strarne adekvatne službe u preduzeću. U radu je dat primer provere funkcionalnosti stuba upravljača ispitivanjem četiri uzorka senzora za merenje pritiska ulja i pokaznog instrumenta na komandnoj tabli stuba upravljača. Rezultati laboratorijskih merenja pritiska ulja za četiri uzorka senzora pritiska ulja nezavisno, prikazani su u tabeli 3.

Tabela 3. Izmerene vrednosti pritiska ulja, [6].
Table 3. Measured oil pressure values, [6].

Tačna vrednost pritiska ulja / Exact pressure value oil (bar)	*Uzorak senzora za pritisak ulja / Sample oil pressure sensor*			
	I	*II*	*III*	*IV*
0	*0*	*0*	*0*	*0*
1	*0*	*0*	*0*	*0*
2	*1,25*	*1,3*	*1,9*	*1,5*
3	*~1,5*	*1,6*	*3*	*1,75*
4	*3*	*~1,5*	*4*	*3*
5	*4,5*	*~3*	*4,6*	*4*
6	*5*	*4,5*	*6*	*~6*
7	*6,5*	*6,7*	*7,1*	*7*
8	*7,5*	*~6*	*7,7*	*7,8*
9	*8,5*	*8,1*	*9*	*8,6*
10	*~9*	*7,5*	*10*	*9*
11	*10,8*	*~9*	*10,6*	*10,8*
12	*11,9*	*11,6*	*11,5*	*11, 8*
početna otpornost uzoraka senzora pri temperaturi Ta=21(℃) initial resistance of sensor samples at ambient temperature				
	I	*II*	*III*	*IV*
Otpornost, Ω /Resistance, Ω)	*291*	*302*	*301*	*280*

Za ovu proveru očitavana je merna skala za pritisk ulja na komandnoj tabli stuba upravljača a prikazana na slici 8. Pre sprovedenih merenja izmerene su otpornosti za svaki ispitivani uzorak senzora i naznačene su takođe u tabeli 3.

Tačka u tabeli 3 koja je prikazana sa prefiksom / ~ / označava vrednost koja je približna navedenoj vrednosti, ali sa malim odstupanjima.

U zavisnosti od potreba kupaca sledi proces usklađivanje elektroopreme sa elektroinstalacijom odnosno projektovanje za svaki model traktora sa kabinom ili bez kabine. Svi procesi se prate kroz program monitoringa i imaju povratnu informaciju i mogućnost korigovanja svih poslovnih procesa. Tako se dobija široka lepeza kvalitetnih proizvoda i povećava konkurentnost na tržištu. U skladu sa nanedenim projektovan je savremeni model poljoprivrenog traktor Rakovica R50 DV bez kabine, modernog dizajna koji je prikazan na slici 11. Ovaj novi model traktora ima ugrađen stub upravljača, slika 12, koji je laboratorijski ispitivan, a deo rezultata je prikazan u radu.

Slika 11. Savremeni poljoprivredni traktor Rakovica R50 DV, [5]
Figure 11. Modern agricultural tractor Rakovica R50 DV, [5]

Slika 12. Stub upravljača kod modela traktora Rakovica R50 DV, [5]
Figure 12. Steering wheel for tractor Rakovica R50 DV, [5]

Istovremeno projektovaje i drugi savremeni model poljoprivrenog traktora Rakovica R60 DV, bez kabine, prikazan na slici 13. Kod ovog modela traktora instument tabla je inovirana odnosno redizajnirana i data je na slici 13.

Slika 13. Savremeni poljoprivredni traktori Rakovica R60 DV, [5]
Figure 13. Modern agricultural tractors Rakovica R60 DV, [5]

Slika 14. Redizajnirana instrument tabla kod modela traktora Rakovica R50 DV, [5]
Figure 14. Redesigned dashboard for tractor Rakovica R50 DV tractor, [5]

Navedena ispitivanja pružaju objektivne informacije o kvalitetu motora i traktora, njegovih sklopova i delova u realnim uslovima rada i uslovima okoline.

Zbog ovih osnovnih obeležija ispitivanja imaju poseban značaj u opštem informacionom sistemu proizvođača i korisnika.

Doprinos ovakvog načina ispitivanja je nesumljiv jer obezbeđuje kvalitet poljoprivrednih traktora i omogućava proizvođačima elektro opreme da poboljšavaju karakteristike svojih proizvoda.

Primenom reinžinjeringa konstruisana su dva nova savremena modela poljoprivrednih traktora sa upotrebom novih senzorskih tehnologija. Proizvodi modernog dizajan su zadovoljili zahteve tržišta i krajnjeg korisnika odnosno rukovaoca traktora. Istovremeno preduzeće je povećalo svoju profitabilnost i steklo konkurentsku prednost.

ZAKLJUČAK

Kako bi preduzeće moglo da uveća korist svojih proizvoda i na taj način ostvari rast produktivnosti neophodno je da izvrši promene. Osnovni pokretač promena u poslovanju preduzeća je spremnost na adaptabilnost zahtevima tržišta. Suštinsko sprovođenje promena je primena reinžinjeringa što podrazumeva poboljšanje poslovnih procesa i upravljanje tim procesima. Primer reinžinjeringa elektroopreme podrazumeva planiranje, dijagnostiku, redizajniranje, inplementaciju i monitoring toka i efekta tog procesa. Istovremeno povećva se proizvodni program traktora u zavisnosti od potreba korisnika što bi rezultiralo većoj konkurentnosti na tržištu. U našim uslovima, kod velikih preduzeća, uvođenje reinžinjeringa je veoma kompleksno i otežano. Bez kontinualnih promena u poslovnim procesima preduzeća gubi se udeo na tržištu.

Savremeni način poslovanja iziskuje neminovne promene u preduzeću koje je blagovremeno potrebno inplementirati. Reinžinjeringom, u ovom slučaju elektroopreme, nastaje transformacija i adaptacija počevši od različitosti proizvodnog asortimana pa do promena u strukturi organizacije i upravljanja samog preduzeća. U okviru promena u poslovnim procesima poslovanja nastaju u :

- Kontinualnom unapređenju proizvoda motora i traktora,
- Timskom radu i intelektulnom kapitalu,
- Fleksibilnom angažovanju radane snage,
- Inovativnim projektima novih modela traktora zasnovanih na potrebama tržišta,
- Većoj konkurentnost kod dobavljača elektroopreme.

Reinžinjeringom jednog dela, u ovom slučaju elektroopreme, pokreće se niz neizostavnih promena u preduzeću, koje se odnose na transformaciju organizacine šeme, redefinisanje biznisa proizvodnog programa, sistema kontrole kao promene organizacine klime i kulture. To u osnovni podrazumeva dijagnostikovanje, redizajn, inplementaciju i monitoring praćenje toka i efekata procesa principa reinžinjeringa celokupnog preduzeća. Promene u preduzeću koje se sprovode poboljšanjima u procesima poslovanja i odnose se na promene u svim poslovnim jedinicama postepeno i sveobuhvatno.

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THE INFLUENCE OF THE PROCESS OF RESEARCHING THE ELECTRICAL EQUIPMENT OF THE TRACTOR IN THE COMPETITIVE ADVANTAGE

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Abstract: The central role and the most important role, excluding the instability and occurrence of crisis business that come from outside the company have processes in the company. In order to maintain a position in a competitive market, it is necessary to define and implement business reengineering business processes in the enterprise. Given that modern technologies have an irreplaceable position in all business processes, it is necessary for manufacturers to adapt to emerging situations. In modern business conditions, tractor and engine manufacturers should provide alternative combinations of replacement of existing tractor equipment with suitable, which supports different applications using the same or new sensors.

This implies extensive testing of samples of electrical equipment prior to installation, according to prescribed procedures and methodology. On the basis of the obtained results and defined technical-functional characteristics, an assessment of the usability of the examined sample and the system as a whole is formed. As business processes of reengineering require subprocesses and new procedures, the necessary laboratory tests and experimental research are carried out. Companies that use their resources best use their resources with their processes, achieving a competitive advantage that results in superior value creation.

The results obtained lead to the acquisition of additional values ie the design of a new or redesigned product with a modern electrical appliance and a modern design.

Advanced technologies for tractor electrical equipment aim to contribute to the overall quality of the tractor and enable the operator of the tractor to be efficient, comfortable, safe and safe in traffic.
This paper gives a part of the exploitation research of the existing electrical equipment and laboratory testing of the functionality of the modern steering column with the associated sensor. The aim of these tests is to search for the alternatives of the electrical equipment components.
The contribution of this type of test is uncertain as it ensures the quality of agricultural tractors and increases the competitive advantage. At the same time, it allows manufacturers of electrical equipment to improve the characteristics of their products.

Key words: *Tractor, electrical equipment, business processes, research, new product.*

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OSNOVNA OBRADA ZEMLJIŠTA U VIŠEGODIŠNJIM ZASADIMA SA ROTACIONOM AŠOVOM

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Sažetak: Osnovna obrada zemljišta u višegodišnjim zasadima i pored tendencija zatravljivanja međurednog prostora još uvek je prisutna u agroekološkim Republike Srbije. Razlog za to su aridni klimatski uslovi kao i nedostatak tehničkih sistema za navodnjavanje za čije korišćenje su potrebne velike investicije. Mehaničkom obradom zemljišta ostvaruju se određene prednosti u odnosu na postupke zatravljivanja. Te prednosti pre svega se odnose na racionalnim raspolaganjem sa vlagom u zemljištu, sprečavanje razvoja štetnih glodara, bolja aeracija zemljišta, kao i efikasno unošenje organskih đubriva.

U radu su prikazana uporedna eksploataciona istraživanja pri obradi zemljišta klasičnim plugom, razrivačem i rotacionim ašovom u višegodišnjim zasadima. Ispitivanjima su obuhvaćeni parametri: dubina obrade, vučni otpor, oterećenje prednjih i zadnjih točkova, brzina kretanja, učinak i potrošnja goriva.

Rezultati istraživanja u ovom radu pokazuju da pored bolje statičke raspoređenosti opterećenja traktora u radu agregata traktor - rotacioni ašov u odnosu na obradu oranjem i razrivanjem, značajne su i uštede u potrošnji goriva po jedinici površine. Potrošnja goriva kod obrade rotacionim ašovom je manja za oko 17 % u odnosu na podrivanje i do 29 % u odnosu na oranje klasičnim plugom.

Ključne riječi: *Traktor, rotaconi ašov, plug, obrada zemljišta, višegodišnji zasad*

* Kontakt autor. E-mail: mzivko@agrif.bg.ac.rs. Rad je deo istraživanja u okviru projekta *«Unapređenje biotehničkih postupaka racionalnog korišćenja energije, povećanja produktivnosti i kvaliteta poljoprivrednih proizvoda, TR 31051,* Ministarstvo prosvete, nauke i tehnološkog razvoja Republike Srbije.

UVOD

Novije tehnologije osnovne obrade zemljišta u višegodišnim zasadima zasnivaju se na racionalnoj potrošnji energije koja ima presudan uticaj na ekonomske efekte voćarske proizvodnje [2,16,18]. Intezivna voćarska proizvodnja podrazumeva gajenje velikog broja biljaka na malom prostoru za čije fiziološke potrebe je neophodno obezbediti veliku količinu vlage u zemljištu. Da bi se obezbedile dovoljne količine vlage u zemljištu koja pripadaju aridnim oblastima neophodno kvalitetna blagovremena osnovna obrada međuredne površine zasada [19].

Osnovna obrada zemljišta ima za cilj da se poboljšaju mehaničke osobine zemljišta i time stvore povoljni uslovi za odvijanje fizičkih, hemijskih, bioloških i mikribioloških procesa [1, 6, 12, 15]. Dobre mehaničke osobine zemljišta omogućuju veću akumulacija vlage u zemljištu kao osnovni preduslov za poboljšanje i ostalih osnovnih tehnoloških osobina zemljišta [3, 20].

Kod klasičnih tehnologija osnovne obrade zemljišta u zasadima veliku primenu imaju raoni plugovi čijim korišćenjem se angažuje velika količina energije, stvara »plužni đon« i na nagnutim terenima uzorano zemljište izlaže intezivnijoj eroziji.

Kod savremenih tehnologija obrade zemljišta u višegodišnjim zasadima koje podrazumevaju racionalnu upotrebu energije primena pluga je svedena na minimalnu meru, ili je potpuno izostavljen kao oruđe za osnovnu obradu. Takve tehnologije mehaničkom obradom zemljišta u višegodišnjim zasadima imaju za cilj da se zemljište samo izdrobi, rastrese i izmeša bez prevrtanja obrađenog sloja čime se znatno štedi uložena energija. Integrisanje više radnih operacija u jednom prohodu doprinosi smanjenju gaženju zemljišta a time i utrošku energije pri obradi [8,9,18]. Vek trajanja zasada, veličina prinosa kao i kvalitet plodova, u znatnoj meri uslovljeni su tehnologijom obrade zemljišta [4, 10].

Mnoga istraživanja ukazuju na činjenicu da obrada zemljišta u višegodišnjim zasadima a pogotovu u klasičnim tehnologijama angažuje veliku količinu energije [5, 11, 13]. Pravilan izbor i adekvatna uopotreba odgovarajućih traktorsko-mašinskih agregata su osnovni uslov za racionalno korišćenja energije u osnovnoj obradi zeljišta. Poslednjih godina u agrarno razvijenim državama sve više se primnjuju razivačka oruđa-čizel plugovi kao i rotacioni ašovi pri osnovnoj obradi zemljišta u višegodišnjim zasadima.

MATERIJAL I METODE RADA

Kod savremenih tehnologija obrade zemljišta u višegodišnjim zasadima koje podrazumevaju racinalnu upotrebu energije, upotrebe pluga je svedena na minimalnu meru, ili je potpuno izostavljen kao oruđe za osnovnu obradu. Takve tehnologije mehaničkom obradom zemljišta u višegodišnjim zasadima imaju za cilj da se zemljište samo izdrobi, rastrese i izmeša bez prevrtanja obrađenog sloja čime se znatno štedi uložena energija.

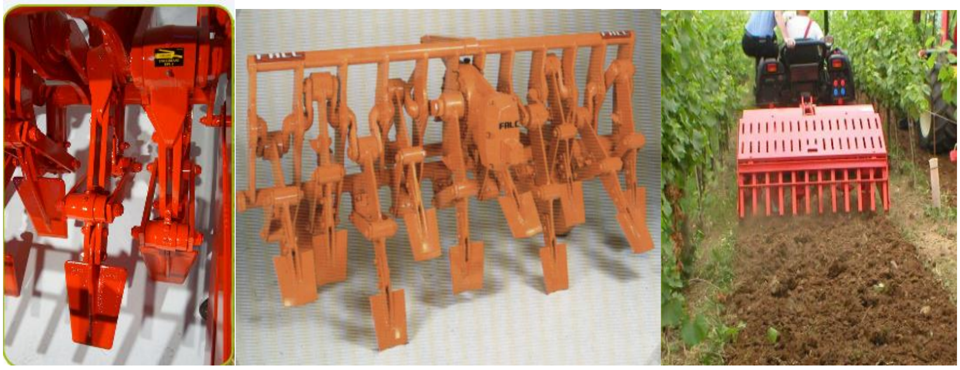
Poslednjih godina u agrarno razvijenim državama sve više se primenjuju razivačka oruđa ili čizel plugovi kao i rotacioni ašovi a prestavljaju vrstu priključnih mašina pri osnovnoj obradi u višegodišnjim zasadima.

Tehnički aspekt primene rotacionog ašova

Prva tehnička rešenja rotacionog ašova pojavljuju se 50-ih godina XX veka, u Holandiji, Engleskoj i Italiji. Ova tehnička rešenja mašina za obradu su rotacioni plugovi tipa “Rotaspa”. Njihov rad je skoro u potpunosti simulirao princip rada ručnog ašova tokom obrade zemljišta. Zbog složenosti konstrukcije i čestih mehaničkih kvarova odustalo se od njhove upotrebe.

Tridesetak godina kasnije pojavio se modifikovan tip “Rotaspa” konstrukcije rotacionog ašova (sl. 1.), koja takođe predstavlja traktorsku priključnu nošenu mašinu sa aktivnim radnim organima. Taktor kao pogonska mašina tokom obrade istovremeno nosi rotacioni ašov i ostvaruje njegov pogon preko priključnog vratila (sl. 2.).

Radni organi su u obliku ašova vezani krajevima nosača na zajedničkom kolenastom vratilu koji im u radu prenosi kretanje. Svaki nosač radnog organa sredinom vezan je preko osovinice za mehanizam (u obliku paralelograma) koje omogućuje njegovo sektorsko kretanje.



Slika 1. Rotacioni ašovi, [15, 25]

Figure 1. Rotary asses (showel) without cladding, [15, 25]

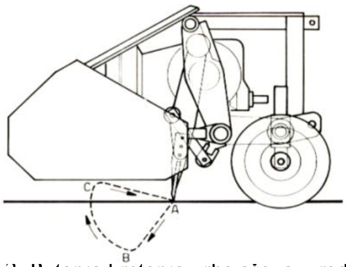
Kolenasto vratilo dobija pogon iz razvodne kutije mašine do koje se prenosnim mehanizmom od priključnog vratila traktora dobija obrtno kretanje. Obrtno kretanje vratila se prenosi na sve radne organe. Ašovi su raspoređeni u vertikalnoj ravni, pomereni za određeni ugao, čime se omogućuje da u procesu rada imaju definisan raspored zahvata.

Razvodna kutija je veza i prenosnik snage između spojnice i kolenastog vratila sa radnim elementima. Ona je smeštena u centralnom delu rotacionog ašova i omogućava fina podešavanja broja obrtaja kolenastog vratila ašova pri konstantnoj brzini kretanja traktora. Time je omogućeno biranje optimalnog režima obrade i maksimalno iskorišćavanje potencijala celog agregata.

Zavisno od stanja zemljišta mogu se birati različite kombinacije između brzine kretanja traktora, broja obrtaja radilice motora, broja obrtaja kolenastog vratila ašova i dubine obrade.

Kružno kretanje od kolenastog vratila i sektorskog mehanizma, saopštava određenu kinematiku (putanja ABC) radnog organa (sl. 2.) koja je karakteristična za proces rada.

Radni elementi su takvom rasporedu koji omogućava miran i ravnomeran rad. Dva radna elementa nikad ne ulaze istovremeno u zemljište, već se to događa u vrlo malim vremenskim razmacima. Time je izbegnut nagli udar elemenata o zemljište, posebno ako se radi na sabijenom zemljištu. Radni ritam je dobro raspoređen, tako da ne dolazi do uzdužnih vibracija koje bi se prenosile na konstrukciju traktora. Pri radu ovom mašinom prisutno je smenjivanje radnih delova sa desne i leve polovine.



Slika 2. Putanja kretanja vrha ašova u radu, [15].
Figure 2. The movement of the peak of the shoulders (showel) at work, [15]

Slika 3. Rešetkasta obloga (rastresač)
Figure 3. Grid cladding (raster), [24].

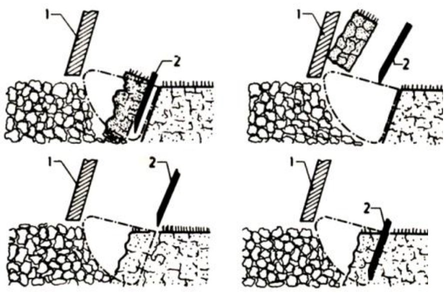
Kolenasto vratilo sa ašovima sa gornje strame može biti pokriveno oblogom kao i kod rotositnilice koja je najčešće rešetkasta (sl. 3.). Obloga u obliku rešetke ima ulogu da sitni (rastresa) odbačene komade zemljišta ašovom i u praksi se često naziva rastresač.

Rastresač je kruto vezan za ram i postavljen tako da sa podlogom zaklapa ugao od oko 45°. Takav položaj obloge pretpostavlja da odbačeni agregati zemljišta udaraju o elemente rastresača pod uglom od 90°. Ugao pod kojim je postavljena rešetka određuje intenzitet dodatnog pojačavanja udarne sile odbačenih komada zemlje.

Tehnološki proces rada

Rotacini ašov pri rada u određenoj meri oponaša riljanje zemjita ašovom kao ručnim alatom (sl. 4.). Svaki radni organ po određenom rasporedu u procesu rada, zaseca sloj zemljišta, tj. seče ga u vertikalnoj ravni koja je nagnuta za određeni ugao u pravcu kretanja mašine. Zatim, zasečeni sloj (komad) kretanjem ašova unazad se otkida u horizontalnoj ravni.

Slika 4. Rotacioni ašov u radu, [15]
Figure 4. Rotary wash in operation, [15]



Slika 5. Šematski prikaz riljanja: 1-obloga; b-ašov, [15]
Figure 5. Schematic view of the cultivation, [15]. 1-coating; 2-ash

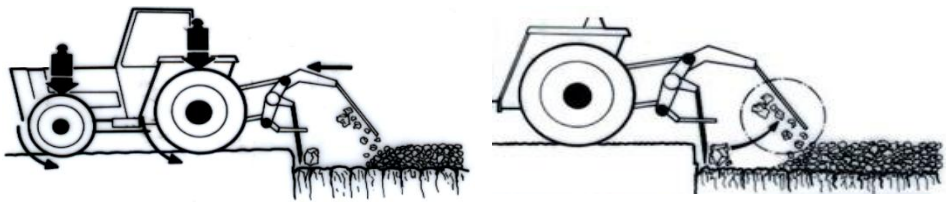
Otkinut ili odsečen komad zemljišta se izdiže i zbog dejstva centrifugalne sile spada sa ašova i udara u oblogu gde se sitni do odeđene mere (sl. 5.). Sitnjenje zemljišta u obradi sa rotaciomi ašovom zavisi od: tipa zemljišta i vlažnosti, položaja obloge i broja obrtaja radnog elementa mašine.

Modifikacija u tenološkom procesu rada se ogleda u tome što odsečenu plasticu mašina ne prevrće i ne pakuje kao kod ručnog ašova. Tako, funkcionisanje ovih mašina je posledica značajne modifikacije mehanizma "Rotaspa", čime je dobijen dosta jednostavan mehanizam i time pouzdanji rad mašine sa neznatno lošijem kvalitetom obrađene površine.

DISKUSIJA REZULTATA

Prednosti primene rotacionog ašova

Lomljenje sloja zemljišta u horizontalnoj ravni radom rotacionog ašova ostavlja hrapavu površinu ispod obrađenog sloja (sl. 6 a.). Takva površina ima povoljan uticaj na vodni režim i mehanička svojstva zemljišta.



a) b)

Slika 6. Šematski prikaz rada rotacionog ašova: a) hrapava površina ispod obrađenog sloja; b) raspored vučnih sila agregata, [15].

Figure 6. A schematic diagram of the operation of the rotary wash: a) rough the surface under the treated layer; b) the arrangement of the pulling forces of the aggregate, [15]

Činjenica da radni organ (ašov) ima kontakt sa zemljištem samo u trenutku zasecanja zemljišta, a da se odvajanje vrši lomljenjem, ističe prednost ovih mašina u odnosu na ostale koje takođe imaju aktivne radne organe (na primer rotositnilice). Pedološke nauke dokazuju da metalne površine radnih elementa treba da imaju što manji kontakt sa zemljištem čime se smanjuje kvarenje njegove strukture.

Konstrukcija ove mašine ima dobro izbalansirane radne elemente a naročito sistem rotirajućeg mehanizma pa zbog toga troši relativno malo snage za svoj rad. Sistem rotirajućeg mehanizma ove mašine doprinosi da 50% vučne sile dobija od prednjih točkova, a 50% od zadnjih točkova traktora (sl.6 b.).

Pri radu rotacioni ašov stvara pozitivnu silu (gura traktor) koja kombinovana sa dobro balansiranom distribucijom vučnih sila je izuzetno korisna u otežanim uslovima rada (rad na nagibu, suvo i teško zemljište i slično). Pogon preko priključnog vratila traktora tzv. prinudni pogon, omogućava dejstvo radnih elemenata na zemljište i visoku koncentraciju energije za razbijanje i sitnjenje zemljišta.

Zemljište obrađeno rotacionim ašovom znatno povećava zapreminu, što dovodi do veće biološke aktivnosti zemljišta. Rotacioni ašov ravnomerno raspoređuje zemljište po celom radnom zahvatu i intezivno ga rastresa tako da se ostvaruje dobra aeracija i ne dolazi do brzog sleganja zemljišta. Obrađena površina zemljišta ostaje ravna, bez slogova i razora (sl. 7.).

Hrapavo i izlomljeno dno brazde je u mogućnosti da akumulira znatno veću količinu vlage. Takva površina je povoljna kod obrade zemljišta podložnog eroziji u kišnom vremenskom periodu ili u humidnim reonima. Rotacioni ašov tokom rada ispod obrađenog sloja zemljišta stvara pukotine koje omogučuju dreniranje viška voda u niže horizonte zemljišta u kišnim periodima.

Rotacioni ašovi se mogu primenivati na teškim i raskvašenim terenima (sl. 7.). Pored toga uspešno se koriste na kamenitim, zaparloženim i zemljištima koja se privode kulturi.

Slika 7. Rad rotacionog ašova na teškom i raskvašenom terenu, [24]
Figure 7. Operation of the rotary shaft on difficult and task-based terrain, [24]

Slika 8. Izgled obrađene površine u vinogradu,[24]
Figure 8. The appearance of the cultivated area in the vineyard, [24]

Eksploatacioni pokazatelji

Eksploataciona istraživanja i iskustva u primeni rotacionog ašova u višegodišnjim zasadima (Italija i druge zemlje EU) su prikazana komparativno u odnosu na raoni plug i razrivač. Podaci o eksploatacionim pokazateljima su preuzeti od italijanskih proizvođača ovih mašina [21]. Osnovni eksploatacioni parameti tri različita agregata u obradi zemljišta prikazani su u tabeli 1.

Tab. 1. Korišćenje vučne sile i raspodela opterećenja traktora u procesu rada, [25]
Tab. 1. Use of traction and distribution of tractor load in the process of operation, [25]

Pokazatelji / vrsta mašine Indicators / type of machine	***Rotacioni ašov Rotary spader(shovel)***	***Plug Plough***	***Razrivač Chisel plough***
Opterećenje Load (-)			
- prednji točkovi front wheels	*1⁄2*	*1⁄3*	*1⁄4*
- zadnji točkovi rear wheels	*1⁄2*	*2⁄3*	*3⁄4*
Vučna sila Traction (%)			
- prednji točkovi front wheels	*50*	*35*	*20*
- zadnji točkovi rear wheels	*50*	*65*	*80*

Razultati ispitivanja (tabela 1.) pokazuju bolji raspored opterećenja na pogonskoj mašini kod rotacionog ašova. Na osnovu toga omogućeno je jednako iskorišćenje vučne sile na prednjim i zadnjim točkovima i sa manjim brojem obrtaja kolenastog vratila motora. Osnovne parametre rada rotacinog ašova, pluga i razrivača, prikazuje tabela 2.

Tab. 2. Tehnički parametri oruđa i rotacinog ašova za obradu zemljišta, [25]
Tab. 2. Technical parameters of tools and rotary ash for soil processing, [25]

Pokazatelji / vrsta mašine ***Indicators / type of machi***	**Rotacioni ašov** ***Rotary spader(shovel)***	**Razrivač** ***Chisel plough***	**Plug** ***Plough***
Brzina kretanja Speed of movement (km/h)	*(4,9)*	*6,1*	*4,20*
Radna širina Working width (m)	*3*	*2,50*	*1,20*
Dubina obrade Processing depth (m)	*0,35*	*0,35*	*0,35*
Potrošnja goriva Fuel consumption kg/h (kg/ha)	*39,2/26,13*	*48,04/31,50*	*19,70 / 34,70*
Učinak ha/h	*(1,18)*	*1,22*	*0,45*

Analizom rezultata (tabela 2.), može se konststovsti da je utrošak goriva po jedinici obrađene površine najmanji sa rotacionim ašovom. Klasičnom obradom zemljišta primenom pluga za 1 ha, potrebno je 1,29, a razrivačem 1,17 puta više goriva. Obrada zemljišta sa rotacionim plugovima ne ostvaruje isti stepen prevrtanja plastice i zaoravanje biljnih ostataka, kao sa plugovima. Pored toga, obradom rotacionim ašovom postižu se povoljniji finansijski efekti do 10% u odnosu na ostale načine redukovane obrade, kao što je razrivanje. To se objašnjava činjenicom da se proces rada rotaconog ašova zasniva na direktnom prenosu pogonske enerije na aktivne radne elemente preko priključnog vratila traktora, čime su izbegnuti gubici koji se javljaju pri obradi priključnim oruđima kao što su plugovi, razrivači, i kultivatori .

ZAKLJUČAK

Primena rotacionih ašova u Italiji i drugim zapadnim agrarno razvijenim državama, pokazuje značajne prednosti primene rotacionog ašova u obradi zemljišta kako u višegodišnjim zasadima tako i u oblasti ratarstva i povrtarstva. Obrada se može izvoditi na veoma teškom, vlažnom, kamenitom, zapuštenom i zemljištu gde nije moguće uspešno primeniti neke druge klasične mašine za obradu zemljišta.

Posle obrade zemlišta rotacionim ašovom, ostaje ravna površina (bez sloga i razora) a izbegnuta je pojava plužnog "đona". Obrađeno zemljište se lakše drenira što je veoma važno kod teških tipova zemljišta, podložnih zabarivanju u kišnim periodima.

U energetskom kao i ekonomskom smislu postižu se zanačajne uštede kroz smanjnu potrošnju goriva. To je i do 30% manja potrošnja pogonskog goriva nego kod obrade plugom, uz nešto slabije prevrtanje plastice i zaoravanje biljnih ostataka.

Tokom obrade i rada rotacinog ašova kao priključne mašine, smanjeno je gaženje zemljišta zahvaljujući ravnomernom rasporedu opterećenja na prednje i zadnje točkove traktora. Pored toga izbegnute su pojave klizanja pogonskih točkova traktora kao i savladavanje većeg nagiba u radu agregata.

U daljim istraživanjima neophodna su potpunija istraživanja parametara kvaliteta načina obrade, čime bi se definisao evidentan uticaj različitog stepena prevrtanja plastice kod zaoravanja biljih ostataka.

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BASIC SOIL TILLAGE OF PERENNIAL PLANTATIONS WITH A ROTARY SHOVEL

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Basic soil tillage in perennial plantations is still present in agro-ecological conditions of R.Serbia despite the tendency for grassing the inter-row space. The reasons for this include arid climatic conditions, as well as the lack of an irrigation system requiring great investments.

Mechanical soil tillage provides some advantages over the procedures of soil grassing. These advantages primarily relate to the rational distribution of moisture in the soil, prevention of the development of harmful rodents, better aeration of soil as well as an effective application of organic fertilizers.

The paper presents comparative exploitation surveys in soil tillage with a conventional plough, subsoilers and rotary hoes in perennial plantations. The exploitation testing covered determination of working depth, working speed, pulling resistance, front and rear wheel load, performance and fuel consumption.

The results of the survey show that apart of having better tractor static load distribution when it is in aggregate with the rotary hoe, this combination has a potential of lowering the fuel consumption.

This aggregate has 17% lower fuel consumption compared to the subsoiler usage and 29% lower consumption compared to the plough usage.

The main conclusion is that the performance indicators of the working methods described should be analysed in further research. To-date experience shows that the operation of the rotary hoe compared to the standard plough results in lower intensity of the soli mixing and lower intensity of plant residues incorporation in the soil.

Keywords: *tractor, rotary shovel, plough, soil cultivation, perennial planting*

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AGRICULTURAL FIELD MACHINERY SELECTION AND UTILIZATION FOR IMPROVED FARM OPERATIONS IN SOUTH-EAST NIGERIA: A REVIEW

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Abstract: A review of agricultural field machinery selection and utilization for improved farm operations in South-east Nigeria was conducted. Proper selection and utilization of machinery effortlessly would boost up and optimize farm production by minimizing unnecessary breakdown/failure, energy and power losses and mismatching of implements to prime movers. These could only be achieved with the aid of performance data of the various field machinery. The review indicated that average performance efficiency of disc plough in South–East Nigeria was 87.11 %, whereas harrow, ridger, rotovator and planter were 86.32 %, 86.78 %, 87.14 % and 86.81 %, respectively. The review further revealed that most studies were focused on a few soil types with few field implements. It was also observed from the review that data obtained for performance of various field machinery vary from one region to another and from one soil type to the other due to variation in ecological soil conditions. Most studies reviewed did not consider the energy and power requirements of the machinery in operation. More so, variations in agro-ecological soil types and conditions require studies of different agricultural zones/areas to obtain data of the performance characteristics of agricultural field machinery that would guide farmers and users of agricultural field machinery in the selection of appropriate machines for their agricultural field operations in order to increase their production at reduced costs. Field test results of some farm machineries were also presented. Prospects for future work were suggested.

Keywords: *Field machinery, performance, selection, utilization, South-east Nigeria.*

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INTRODUCTION

Agricultural field machinery refer to those machines/implements basically used in the farm for field operations such as land clearing machines; tillage or seed bed preparation machines; seed planting machines, fertilizer applicators, mechanical weeding machines; sprayers for weed and pest controls; harvesting machines and transporting machines [1]. These machines are powered by prime movers (tractor) and are used in the farm for agricultural field operations. Most of these machines are fully mounted/ hitched, semi-mounted, self-propelled or trailed implements. Modern agricultural operation demands the application of these field machinery and implements in different farm operations from field clearing to harvesting operation [2].

There are many land areas available in different areas of the world today, but not all the lands are suitable for crop production, and in order to make them economically feasible for agricultural production, different mechanical tillage operations will be conducted. The most important operations required include: adequate seed bed preparation for seed planting, germination, proper growth of the crop, mechanical weed control or application of herbicides/pesticides, fertilizer application, harvesting and conveying of farm produce to the final/designed destination [3]. The authors further noted that farm machineries are designed to carry out these agricultural operations at specified time and cost. But when these designed purposes are not realized, it shows that such machinery/equipment and their power units are doubtful.

Yahanna and Ifem [4] posits that an experienced farmer endeavors to utilize in full capacity agricultural mechanisms such as farm machinery, pest and weed control measures, seed planting, fertilizer and water applications, energy supply, livestock feeds etc., in order to optimize production at reduced cost. They added that farm machinery are devices that enable other inputs achieve the needed results and can be believed that farm machinery and the system of operation generally make up the field of farm mechanization. Most of the increased crop production which was recorded over the years in agriculture is attributed to principally the high utilization of appropriate machines and implements [5]. Oduma *et al.* [6] noted that farmers are prudent and much concerned about the quality and quantity of the performances of their machines during operation to ensure that they are able to recover the expenses incurred either in hiring/purchasing or maintenance of such machinery. Sale *et al.* [7] maintained that agricultural operations are time dependent, in order words, they are timely and cost intensive. Accessing the field performance of farm machines is therefore considered economically wise for better selection, optimization and proper farm scheduling.

Oluka [8] also noted that it is important to know the various indicators associated with the cost of owning and operating farm tractors to enable a farmer know if he/she is making profit or loss in the farm business by using tractor and implements (such as plough, harrow, ridger, rotovator, planter etc.). Withney [9] asserts that effective machinery utilization and management demand knowledge of the performance data on the efficiencies of the available machines to be able to meet up with a given work schedule and to establish a balanced system of mechanization which will match the capacities of different equipment. There are considerable differences in operating conditions, such as land topography, hardness/stoniness of the soil, surface roughness, and traficability of the soil; machines/implements may be assessed on a short time in productive operation - equivalent to working speed trials or evaluated over-time taking into account the delays encountered during operation [4]. Braid and Gwarzo [10] suggested that machine performance should be examined if an accurate knowledge of it is to be secured.

The performances of farm machinery are conversely influenced by different factors. These factors include the power units, machine/implements condition, nature of field, crop type, weather condition, soil type/condition and system of management.

Onwualu *et al.* [2] stipulated that it is important to ascertain how a machine/implement carries out a given farm operation and the rate with which it performs it. This information is necessary because it promotes machinery management and utilization and other economic aspects in addition to timeliness of farm operations. According to them timeliness is the capacity to carry out an activity in a period that the quality and quantity of the output are broadly and effortlessly optimized. Capacitive performance is an indicator that determines how a given machine/implement completes a work schedule within the limit of time [7]. Performance of any farm machine suggests solutions to the question, "will the machine handle and complete a given field operation within the allowable constraints of time considering the variations in field conditions"? Or will it be a bad investment not withstanding its cost? Tractor and its hitched implements supposed to perform tasks adequately in seed planting, mechanical weeding, application of fertilizers, pest/weed controls and harvesting of crops at reduced damage of crops; also prepare suitable seed bed while maintaining the moisture content of the soil; enhance good soil aeration and the required environmental condition for crop growth/development and protect the soil against erosion and nutrient/sediment losses etc.

Furthermore, energy is another significant indicator in farm operations. According to Updhyaya *et al.* [11], it plays an important role in different land tillage operations, seed planting operation, application of fertilizers, pest/weed controls harvesting of crops etc.,

Therefore, fuel cost of tillage and/or agricultural productivities should be effortlessly kept at a reduced level to ensure that no amount of operation will lead to high operation cost per hour or keep the cost at a prohibitive level. Thus, machinery operation should be simple and cheap, consistent and low in fuel consumption [12].

Bukhari and Baloch [13] observed that operation speed, implement effective working width and cutting depth, soil type/conditions and operator's skill influence fuel (energy) consumption rate. It therefore means that size of implement and speed of operation should be matched to machine size to improve the field capacitive performance of the machine [14]. The performance efficiencies of farm machinery can generally be evaluated by the rate at which they carry out their field operations and the quality and quantity of production. Gbadamosi and Magaji [15] stated that machine field capacity is the rate at which the machine can cover a given field operation within the limit of time. Kaul *et al.* [16] noted that effective capacity is evaluated by the rate of working of implement measured in hectares per hour, and that the indicators involved are the implement operation width and the working speed with the allowance for time loss, in turning at the end of the field, adjustment and servicing of the machines. The efficiency of machines/implements indicates how good the machine can perform its functions. According to [6], an experienced farmer is usually conscious of the effective and efficient operation of his/her farm machinery because poor operation or improper utilization of the equipment may lead to great operating loss and minimizes production or result in total loss of money/productivity.

Anazodo *et al.* [17] noted that, due to some differences in the agro-ecological soil conditions, performance data of the field capacities of machines under varying soil type/conditions is very essential for machinery selection; the performance data are the essential parameters for assessing the performances of farm machinery. But regrettably this information are not provided to farmers or farm managers in Nigeria by the producers of the machines to guide the farmers in assessing and making proper selection of the machine/implement prior to purchase.

However, huge amount of money is invested by farmers annually in purchasing/hiring, operation, maintenance and management of agricultural field machinery. Most of these machines breakdown/fail unnecessarily during operation, in addition to high energy and power losses incurred in operation due to improper selection of machinery that suit the soil condition and/or mismatching of the implements with the prime mover. Knowledge of the performance characteristics and power unit of the machines will effortlessly ameliorate the plight of farmers, and help them to improve and optimize their production when they make better selection of machines that will match their soil type/conditions. The objective of this work is to review the selection and utilization of agricultural field machinery in South- East Nigeria for improved farm operations.

POTENTIAL IMPACT OF MACHINERY PERFORMANCE AND SELECTION

Today's competitive agricultural market demands better utilization/ management of resources and minimization of operating costs so as to optimize production and increase profits. One of the major costs of any agricultural production system is machinery cost. Increasing the performance efficiency of farm machinery may lead to a serious cost reduction. Farmers like other business ventures strive to cover up their expenditures in addition to the cost of the machinery. This is why [4] noted that an intelligent and well experienced farmer tries to make proper use of farm inputs (seeds, fertilizers, herbicides or insecticides, irrigation water and farm equipment) so as to reduce cost. In Nigeria, farm mechanization technology has continually been import - oriented. Agricultural machines and equipment are imported from different countries into Nigeria to aid the different farm mechanization decisions of the government [18]. Presently, the cost of importation of agricultural machinery has been sky rocketed due to the devaluation of the local currency and to operate within such a bad economic condition, machinery managers, owners and/or users must be careful in selecting and purchasing new machinery. It is therefore necessary that the users should know how a machine performs a given task and the ease and/or rate with which it does the work without failure or breakdown and at minimal wastage of energy and operation time.

According to Grisso *et al.* [19], field efficiency is an essential factor for assessing the field capacity and for adopting necessary management policies. The authors maintained that machine capacity is used to ascertain how machine will carry out its functions and that it ensures timeliness of operation. Von Bargen *et al.* [20] maintained that field efficiency implies completing a given field task at minimum waste of time, energy and other farm resources. According to them, timeliness describes the actual time the field operation should take, initiate turning and other non- productive time. Field efficiency explains the relative magnitude or proportion of the total productivity of any given machine/implement based on the nature of the farm and the maximum production of the machine; and depends on the factors such as: theoretical field capacity of machine/implement, machine maneuverability, machine repair in the field, pattern of the field, shape of field, size of farm land, operator's experience/skills, crop moisture content, nature of crop yield and soil type/conditions [21]. Generally, field efficiency takes into account time losses and the ability to use the full width of machines/implement. Effective field capacity is the rate of field coverage or crop handled in a particular period based on total field time. Theoretical field capacity on the other hand is the actual rate of performance achieved when a machine carries out its function 100 % of the time at a particular working speed applying 100 % of its working width.

It represents the time taken by a machine to operate in the field from the commencement of the field operation until the end of the work. Table 1 shows the ranges of field efficiency at different speed range for some of the farm machines as observed by [1].

Table 1. Range of typical field efficiencies and implement operating speeds.*

Field Operation	Equipment	Field efficiencies, %	Operating speeds, kmh^{-1}
Tillage	Moldboard plow	88-74	5 - 9
	Disk harrow	90-77	6 - 10
	Spring-tooth or spike-tooth harrow	83-65	6 - 12
	Field cultivator, Chisel plow	90-75	6 - 9
Cultivation	Row crop cultivator	90-68	3 - 9
	Rotary hoe	88-80	9 - 20
Seeding	Row planter with fertilizer	78-55	7 - 10
	Grain drill with fertilizer	80-65	5 - 10
	Broadcaster	70-65	7 - 10
	Potato planter	80-55	9 - 12
Harvesting	Mower-conditioner	95-80	5 - 9
	Rake	89-62	6 - 9
	Baler, rectangular	80-65	5 - 10
	Baler, round	50-40	5 - 19
	Forage harvester, shear bar	76-50	6 - 10
	Combine	90-63	3 - 8
	Corn picker	70-55	3 - 6
	Windrower, swather	85-75	6 - 10
	Potato harvester	90-50	3 - 6
	Cotton, spindle picker	90-65	3 - 5
Miscellaneous	Sprayer	80-55	7 - 10
	Anhydrous ammonia applicator	65-55	6 - 9
	Rotary stalk chopper, mower	85-65	6 - 10
	Fertilizer	90-60	6 - 10

*Source: Hunt [1].

Field efficiency varies inversely with the machine theoretical capacity. One may intuitively think that a little time lost with a big machine implies heavy waste in potential production than a similar time waste with a small machine. Field capacity of a machine/implement also depends on the working speed. Thus, there may be a drop in the field efficiency if the machine/implement working speed is increased. An increase in travel speeds will decrease the productive working time needed.

However, when the time losses remain effectively the same, there will be drop in the field efficiency of the machine. Such a result according to [1], suggests that as much as there is a speed consideration, it is not good management to attempt to reduce field efficiency; therefore, it is not good operation to use slow speeds to achieve high field efficiency. Since high field capacity and/or material capacity can possibly be achieved with fast working speeds, an experienced operator should assess the soil and crop conditions and thus operate with high speed while maintaining the best quality of operation.

In field operation speeds may be influenced by such factors as: machine overloading, poor steering operation, careful operation to avoid loss of functional and structural damage to the machine owing to rough ground surface and being prudent in handling materials. Machine overloading may have the greatest influence on the efficiency of the machine and may lead to failure/breakdown; while material handling has least effect on the efficiency of machine unless the machine is not in good working condition.

Values of machine capacities are applied in scheduling field operations, its power units and labour as well as determining machine operating costs. According to [4], different machines have different field efficiencies, though depending on the system of operations, soil type/ conditions and the system of management. Yohanna [22] and Yohanna [23] studied the field efficiency of some selected farm machinery in Nasarawa and Plateau states of Nigeria, but due to variation in agro-ecological areas and/or soil conditions according to [17], data obtained in the studies cannot guide farmers effectively in South-East Nigeria in selecting appropriate machinery that will suit their soil condition. Tables 2 presents the field efficiency of some tractor hitched implements in Nasarawa and Plateau State.

Table 2. Field efficiency of some selected farm machinery in Nasarawa and Plateau States, Nigeria.

Implements	***Field efficiency (%)***
Disc plough	*68*
Tandem harrow	*57*
Ridger	*56*
Combine seed drill	*56*
Boom sprayer	*60*
Combine harvester	*48*

Source: Yohanna [23].

Oduma et. al [24] evaluated the performance characteristics of agricultural field machineries in south- east Nigeria (Table 3) and observed that the average performance efficiency of plough was 87.11 %, while harrow, ridger, rotovator and planter recorded average field efficiencies of 86.32 %, 86.78 %, 87.14 % and 86.81 %, respectively. However, the highest field efficiency for all the implements was obtained on sandy-clay soil with overall average efficiency of 87.35 %; followed by clay-loam that gave average efficiency of 86.53 % and least was 86.21 % obtained on loamy sandy soil. The authors noted that it could be due to low aggregation stability, high moisture content and low decomposed organic matter found in sandy-clay than other soil type as also observed by [25]. This is in agreement with the observations of [26] that soil type and condition are cardinal factors affecting field performance of farm tractors through their effect on the hitched implements and tractor traction force. It also confirms the findings of Smith [27] who posited that the performance of plough varies considerably according to the soil type. Despite the detailed time study made by these authors, they could not cover all the farm machinery used in farm operation in the South- east region of Nigeria. Their studies mostly focused on tillage and planting implements.

*Table 3. Field efficiency of some selected farm machinery in South-East Nigeria**

Soil textural class	***Implement performances (field Efficiency, %)***				
	Plough	*Harrow*	*Ridger*	*Rotovator*	*Planter*
Clay-loam	*87.41*	*82.06*	*84.41*	*87.13*	*86.18*
Clay-loam	*86.48*	*87.75*	*87.33*	*88.23*	*88.30*
Loamy-sandy	*87.47*	*85.83*	*87.51*	*84.91*	*85.31*
Sandy-clay	*85.12*	*86.85*	*86.64*	*87.78*	*86.35*
Sandy-clay	*88.07*	*89.12*	*88.03*	*87.64*	*87.92*
Average	*87.11*	*86.32*	*86.78*	*87.14*	*86.81*

*Source: Oduma *et al.* [24].

Performance efficiencies of chisel and disc ploughs and their impact on some physical properties of soil in Sudan was studied. Results of the study revealed that disc plough had field efficiency of 79.39 % with average fuel consumption rate of 10.6 l/ha while the chisel plough recorded field efficiency of 73.4 l/ha and average fuel consumption rate of 13.47 l/ha. However, their study centered on the plough tested on one soil type, other tillage implements and their power requirements were not considered; thereafter, they recommended that more investigations are needed to verify the impact of the ploughs under study on the physical properties of different types of soils in the area.

Sale *et al.* [7] evaluated the performance of some selected tillage implements in Samaru, Zaria. The study only considered one soil type/ textural class; and because of variations among soil types in an ecological area, results of such study cannot provide enough information that may guide farmers in selecting machines for their agricultural field operations. Saeed [28] investigated the performance efficiency of tractor – hitched tillage tools in clay soil in Urmia, Iran. This study was also based on only one soil type and because of the same reason, the results may not guide farmers properly in machine selection to be used in other soil types; furthermore, Iran and South-east Nigeria may not have the same soil type with same properties/conditions; there must be differences; in which case, farmers in Nigeria may not use data from such study area to select their farm machinery.

Olatunji [29] evaluated disc plough performance on sandy- loam soil at different moisture levels in Ilorin. Dimensional analysis approach was used to develop model expressions relating the cutting depth, disc plough weight and draught force on sandy-loam soil. Despite the detailed study, did not consider the energy requirements of the implement for operation; and the study was conducted on only one soil type with only one tillage implement. These may not be enough to guide machine users in implement selection because of variations in soil type and conditions as emphasized earlier.

Finally, because of these variations that exist in the ecological soil types/conditions, [17] pointed out that performance data of field efficiencies under different soil conditions are very necessary for tractor and implement selection as these were essential parameters for measuring and evaluating performances of farm implements. Such data are not provided to agriculturists or farmers in Nigeria (by implement manufacturers) especially in the local areas to aid the farmers or users of the machines evaluate and possibly make suitable selections of the equipment before purchase.

Tractor Capacities

In selecting reasonable field efficiency for a tillage operation, it is necessary to consider the effectiveness of the prime mover (tractor) in converting engine power to drawbar power. Nothing may be done to minimize power losses from the engine to the axle. Adequate maintenance operation may increase the efficiency of converting fuel energy into axle power but little or nothing can also be done to minimize energy losses. However, when considering losses from the farm tractor axle to the drawbar, energy is usually lost in order to create traction force applied to the tool which causes the implements to move through the soil [30]. This energy loss depends on the type and weight of the tractor, field conditions, and the load being pulled [31].

It is essential to know that drawbar force or power is the product of pull force and speed; where an infinite number of pull force and operation speed may be used to achieve the same power. Wheel tractors are aimed to work at higher operational speeds (higher than 8.0 km/h) and with lower drawbar forces. If low forward speeds (under 5.5 km/h) and large pull forces are to be constantly used, track layers should be considered. Table 5 shows the typical farm tractor efficiencies. The tractors recorded the same crankshaft and PTO powers of 100% and 85%, respectively with maximum drawbar powers varying from 50 to 75%.

Table 5. Typical tractor efficiencies

Tractor type	***Rated crankshaft power (%)***	***PTO power (%)***	***Drawbar power (maximum), %***	***Drawbar power (normal),%***
2WD	*100*	*85*	*50*	*40 - 45*
FWA	*100*	*85*	*55*	*45 - 50*
4WD	*100*	*85*	*60*	*50 - 55*
Track	*100*	*85*	*75*	*65 - 70*

Note: PTO and Drawbar power are given as a percentage of the rated crankshaft power. Source: William [31].

INSTRUMENTATION AND EVALUATION

In order to obtain data on the performance of agricultural field machinery, parameters such as the soil physical properties/conditions that affect machine performances, machine operational speed, productive time, effective width of operation, depth of cut and mass of material handled have to be determined. Some custom designed and/or specially developed instruments/equipment are used by various researchers to determine the soil physical properties. Thereafter, the performance indicators such as the field efficiency (a major indicator for machine selection), effective field capacity, theoretical field capacity, material capacity, and power and energy requirements are evaluated.

The machine speed can be selected or determined by noting the working or operation distance of the machine and time taken to cover such distance and evaluated using Equation (1) [6]:

$$S_w = \frac{Dw}{Tt} \quad (1)$$

Where: S_w = Working speed, kmh^{-1}; D_w = Working distance, km; T_t = Total working time, (h)

The productive time used in the operation is evaluated as expressed in Equation (2):

$$T_e = T_t - T_d \tag{2}$$

Where: T_e = productive time, hr; T_t = Total time spent on entire row length operation, hr; T_d = Delay (idle) time, hr.

The delay or idle time includes, time for refilling fuel tank, time for repair of breakdown/adjustments, turning time and any other idle moment observed during operation except operators personal time.

The effective width of operation can be measured using measuring tape and the depth of cut can be selected or measured using wooden meter rule [1]. A weighing scale with accuracy of 0.1 kg and capacity of 520 kg is used to measure the mass of materials handled.

Evaluation of Performance Indicators of Agricultural Field Machinery

The various performance indicators considered in machine selection include: machine field efficiency, time efficiency, theoretical field capacity, effective field capacity, material capacity, energy consumption rate and power requirements of the machine. These indicators are essential factors for assessing the machine capacities and for adopting necessary management policies. They are used to ascertain how effective a machine would carry out its function and ensure timeliness of operation [19].

Time efficiency

Time efficiency is a percentage reporting the ratio of the time a machine is effectively operating to the total time the machine is committed to the operation [1]. After determining the productive and the total time for each operation, the time efficiency can be obtained from Equation (3), according to [1]:

$$\text{Time efficiency} = \frac{Effective\ operating\ time}{total\ time\ of\ operation} \tag{3}$$

Field efficiency

The field efficiency is determined from the Equation (4) suggested by Kepner et al [5]:

$$\mathcal{E} = \frac{100Te}{Tt} \tag{4}$$

Where: $\mathcal{E}$ = field efficiency, %; T_e = actual working (productive) time, (h); T_t = total working time = (T_e +T_d), hr; T_d = delay or idle time.

Effective field capacity

The effective field capacity is determined by noting the speed of operation, implements working width and the field efficiency of the machine; and then evaluated from Equation (5) suggested by Hunt [1]:

$$Ce = \frac{Swe}{c} \quad (5)$$

Where: Ce = effective field capacity, ha/hr; S = speed, km/hr [mi/hr]; W = rated width of implement, m; e = field efficiency as a decimal; c = constant, 10.

Alternatively, the effective field capacity can be evaluated from Equation (6) as proposed by Kepner (1982):

$$Ce = \frac{WS}{1000}\,\varepsilon \quad (6)$$

Where: w = effective working width of machine, m; S = operation speed, km/h^{-}1; ε = field efficiency, %; C*e* = effective field capacity, ha/h.

Theoretical field capacity

The theoretical field capacity can be determined by rearranging the expression suggested by [15] for field efficiency as given by Equations (7) and (8):

$$\mathcal{E} = \frac{Ce}{Ct} \quad (7)$$

By rearrangement,

$$C_t = \frac{Ce}{\mathcal{E}} \quad (8)$$

Where: C_t = theoretical field capacity, ha/hr; *Ce* = effective field capacity, ha/hr; Ɛ = field efficiency, decimal.

Alternatively, the theoretical field capacity can be evaluated using Equation (9), [21]:

$$TFC = W_t * V_t * K \quad (9)$$

Where: TFC = theoretical field capacity, ha/hr; W_t = theoretical operation width, m; V_t = theoretical operation speed, km/h^{-}1; K = constant = 0.1.

Or by using Equation (10) suggested by Onwualu et al [2]:

$$C_t = SW \quad (10)$$

Where: C_t = theoretical field capacity, ha/h; S = speed of operation of machine, km/hr; W = effective width of operation of machine, m.

Material capacity

The machine material capacity is determined by noting the speed of operation, implement working width, the field efficiency of the machine and the weight of soil scooped (for tillage implements), but for the planter, the quantity/weight of seeds loaded in the hopper; and for harvester the weight or quantity of seed/crop handled in a given time is obtained from the Equation (11) [1]:

$$M = \frac{Swey}{c} \qquad (11)$$

Where: M = material capacity, km/h-1; y = yield/mass of material handled, kg/m^2; s = implement/machine speed, km/hr; w = implement working width, cm; e = implement field efficiency, %; c = constant = 10.

Power requirements for tillage implements

Measurement of draft: Draft is the power, in relation to pull-type or mounted implements, actually required to pull or move the implement at uniform speed. Draft is calculated due to drawbar power using Equation (12) [1]:

$$D = \frac{C \times DBP}{S} \qquad (12)$$

Where: *D* = draft, kN; *C* = constant = 3.6; *DBP* = drawbar power, kW; *S* = travel speed, km/h-1.

***Drawbar*:** The drawbar power is estimated from Equation (13) suggested by [1] as:

$$\text{Drawbar power} = \frac{Total\ draft,\ kN \times speed,\ km^{-1}}{3.6(constant)} \qquad (13)$$

Fuel consumption

A graduated cylindrical container may be used to measure the amount of fuel required to refill the fuel tank of the tractor immediately after a given operation as used by [12]. This measurement will provide the quantity of fuel consumed during any operation. The fuel consumption rates can be calculated in liter/ha or liter/hr as expressed in Equations (14) and (15) and suggested by Alnahas [25]:

$$\text{Rate of consumption (l/ha)} = \frac{Reading\ of\ cylinder,\ litres}{Area\ of\ land\ covered, hacters} \qquad (15)$$

$$\text{Rate of consumption (l/hr)} = \frac{Reading\ of\ cylinder,\ litres}{Time\ taken\ to\ coverthe\ land\ area, hours} \qquad (16)$$

CONCLUSION

Physical characteristics/conditions of soil has great influence on the performance of agricultural machines especially tillage implements while crop type and field condition has effect on planting and harvesting machines. It is a good culture to know the type, condition/characteristics of soil/field before engaging machines for any operation. Furthermore, knowledge of performance characteristics, energy and power requirements of field machinery will help farmers, farm managers and users of farm machinery to make proper selection based on soil type/condition for their agricultural operations to avoid or minimize unnecessary breakdown/failures, mismatching of implements to prime movers, loss of energy, power and time during operation and to increase production and for better management of the machinery at reduced cost.

Average performance efficiency of disc plough in South- east Nigeria was 87.11 %, while harrow, ridger, rotovator and planter were 86.32 %, 86.78 %, 87.14 % and 86.81 %, respectively.

Most studies were focused on a few soil types with few field implements. It was also observed from the review that data obtained for performance of various field machinery vary from one region to another and from one soil type to the other. Most studies reviewed did not consider the energy and power requirements of the machinery in operation.

Recommendations for Future Works

Based on the above conclusion, the following recommendations are made for future studies:

i. Differences exist in soil/field conditions among different agro-ecological areas; it is therefore recommended that studies should be conducted in every agricultural zone/area to obtain data on machine/implement performances based on soil/field conditions which will guide farmers in selecting proper machines that would suit their areas for increased production.

ii. Studies should be conducted with all the agricultural field machinery and on all the dominant soils used in farm operation, if comprehensive performance data for machine selection is to be obtained in South–East Nigeria.

iii. Farmers, farm managers and users of farm machinery should strictly use the performance data of machines in selecting proper machines for their farm operations to avoid mismatching of implements, failure/breakdown and energy loss during operation.

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SELEKCIJA POLJOPRIVREDNE MEHANIZACIJE I POBOLJŠANJE POLJOPRIVREDNIH OPERACIJA U JUGOISTOČNOJ NIGERIJI: PREGLED

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Sažetak: Prikazan je pregled odabrane primene i korišćenja poljoprivrednih mašina na terenu za poboljšanje rada farme u jugoistočnoj Nigeriji. Pravilnim odabirom i upotrebom mehanizacije bez napora bi se povećala i optimizirala poljoprivredna proizvodnja minimiziranjem nepotrebnih kvarova, gubitaka energije i neusklađenosti uređaja sa pogonskim motorima. To se može postići samo uz pomoć podataka o performansama različitih mašina na terenu.
Pregled je pokazao da je prosečna efikasnost rada plugova u jugoistočnoj Nigeriji bila 87,11 %, dok su drljača, kultivator, rotofreza i sadilica imale efikasnost od 86,32%, 86,78 %, 87,14 % i 86,81 %, respektivno.
Pregled je dalje utvrdio da je većina studija bila usredsređena na nekoliko tipova zemljišta sa nekoliko polja. Iz pregleda je takođe uočeno da podaci dobijeni za upotrebu različitih terenskih mašina variraju od jednog do drugog regiona i od jednog tipa do drugog tipa zemljišta, zbog variranja ekoloških uslova.
Većina razmatranih studija nije uzela u obzir zahteve mašina za energijom i snagom.

Varijacije u agroekološkim tipovima i uslovima zemljišta zahtevaju studije različitih poljoprivrednih zona/područja kako bi se dobili podaci o karakteristikama rada poljoprivrednih mašina na terenu, koji bi usmerili poljoprivrednike i korisnike poljoprivredne mehanizacije u odabiru odgovarajućih mašina za njihovo određeno poljoprivredno zemljište. A tako određenim operacijama na terenu povećava se i njihova proizvodnja uz smanjene troškove.
Takođe su predstavljeni rezultati terenskih ispitivanja nekih mašina na farmama.
Predložene su perspektive za budući rad.

Ključne reči: *Terenske mašine, performanse, selekcija, korišćenje, jugoistočna Nigerija.*

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EFFECT OF DRYING METHOD ON FUNCTIONAL PROPERTIES OF YAM (*Dioscorea* sp.) FLOUR

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***Abstract*:** The effect of drying method on functional properties of five different yam flour varieties namely, white yam, purple yam, yellow yam, water yam and three leaves yam were studied using oven, solar and sun drying method. The functional properties were determined using AACC approved method. Results revealed that White yam recorded wettability range of 173.22 – 181.31 secs while the purple yam had wettability range from 151.69 to 201 secs, the three leave Yam, had wettability range from 138.41 to 190.20 secs, the water yam and yellow yam recorded wettability range from 143.62 to 182.11 secs and 153.42 to 174.34 secs respectively. Result also indicated that white yam recorded water absorption capacity (WAC) range from134.32 to 146.11, while purple yam had WAC range from 134.32 to 145.46; three leave Yam, water yam and yellow yam recorded from 129.56 to 138.11, from 133.58 to 163.21 and from 128.34 to 143.88 respectively. Furthermore, white yam, purple yam, three leave yam, water yam and yellow yam respectively recorded swelling power range from 11.84 to 12.63, from 11.14 to 11.82, from 11.28 to 12.66, from 12.19 to 12.38 and from 11.68 to 11.96. The three leave yam recorded the highest water absorption capacity which makes it likely to have least shelf life stability as compared to others because of the ability of absorbing water from a humid atmosphere. Results of the analysis of variance (ANOVA) on the effect of drying methods on the functional properties of the yam varieties showed significant difference at 5% and 1% probability level while the yam varieties did not show any significant different on the functional properties of the yam flour varieties.

Key words: *Drying method, functional properties, yam flour, wettability, absorption capacity.*

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INTRODUCTION

Yam is a tuberous crop with great economic value in the whole world especially tropical West African region. It belongs to the family *Dioscoreaceae* and genus *Dioscorea* that produce tubers and bulbils or rhizomes. Among many other species of *Dioscorea* genus the following are of economic importance, *Dioscorea rotundata, Dioscorea alata, Dioscorea Cayenesis, Dioscorea esculenta, Dioscorea dumentorum, Dioscorea bulbifera, Dioscorea trifida, Dioscorea opposita and Dioscorea japonica.* However, among these species only *Dioscorea rotundata, Dioscore aalata, Dioscorea esculenta, Dioscorea cayenesis, Dioscorea dumentorum* and *Dioscorea bulbifera* are edible [1].

Yams are broadly distributed all over the world, but their circulation concentrated more in the tropical regions. It forms an important crop and food source for tropical countries such as; West Africa, West Indies, East African, America, China, Japan, Philippines, Madagascar, Southeast Asia, South Caribbean, Malaysia, South Pacific Island, Korea and Papua New Guinea [2]. In most of these countries, yam constitutes a good portion of the source of dietary calories of their population, while in some countries like; Japan and China, yam contributes significantly to their industrial raw materials, especially in the areas of pharmaceutical and brewery industries. They have extended to production of non-grain ethanol as an alternative to fuel using yam, cassava and potato [3]. According to FAO [4], the trend of global yam production states that Africa account for about 96% of world production of yam, with Nigeria alone being responsible for nearly three quarters of the world total production; 73.8% of African total production, 35.017 million metric tonnes/year [5]. According to report of IITA [6], most of the world and African yam production is concentrated in the "yam belt" starting from Cote d'Ivoire, through Ghana then Togo, Cameroon and Nigeria, where yam is not just a food security crop but an indigenous food crop that is harmonized into socio-cultural lives of the people. Nigeria is the largest producer of yams in the world, accounting for over 76% percent of the world production [7]. IITA [7] reported that more than 2.8 million hectares of land is under yam cultivation annually in Nigeria.

Yam tubers can be processed using different methods. It could be dried and processed into yam flour. Yam is one of the common staple foods in Nigeria. It could be used in making livestock feed and in industrial starch production [8], [9]. It is one of the major tuber crops making impact in the Nigeria economy, in terms of capacity and value of production

Functional properties provide relevant information on the behaviour of components of food products during processing, such information is very vital in the successful incorporation of unconventional food ingredients in the existing food formulation. Blending one flour with another flour might result in some technology difficulties which can impair the qualities of the product [10]. The dough properties play vital role in the quality of baked products whereas the visco-elastic properties of the flour are also a source of understanding of the dough handling behaviour in the preparation of bakery products [11].

Some vital functional properties are water absorption capacity (WAC), oil absorption capacity, water binding capacity (WBC), swelling power (SWP) emulsification and solubility.

WAC refers to the total amount of water held by a starch gel under a specific state or condition. It is therefore a measure of the ability of the food product to entrap large amount of water such that exudation is prevented [12]. Previous works on WAC of starch based food materials indicate that it is highly dependent on crystalline properties of starch [13]. Sittu et al. [14] in their work on the functional properties of baking flour reported that baking quality is a function of WAC of the flour whereas Jackel [15] maintained that flour with increased WAC would result in favorable characteristics of final product as the product will remain soft for a longer period with improvement in texture and reduced cost. Ezeocha et al. [16] also reported that WAC is affected by the size and shape of starch –based food product as well as the presence of protein, lipids and salts in such food while WBC is affected by the presence of minerals like phosphorus. Abiodun and Akinoso [17] further observed in their work on the functional properties of trifoliate yam that the water absorption capacity, solubility and swelling power were more dependent on pre-treatment methods than the harvesting periods and drying methods.

Swelling power which is a measure of the maximum increase in volume and weight undergone by the starch granules when they are allowed to freely swell in water is an indicator of the strength of the hydrogen bonding between the granules [18]. Rasper [19] explained that the swelling and solubilisation characteristics of various starches which are indicators of strenght of the miscellular network within the starch granules affect its rheological properties. He further noted that the ability of starch granules to swell and yield a viscous paste has been the most important practical properties of starch because of its effect on the rheological behaviour. WBC is a measure of the associative force between the starch granules of food ingredients. It is indicator of the magnitude of the molecular surface of the starch granules available for binding with water molecules [20]; [21].The aim of this research work is to obtain useful data on the functional properties of some selected varieties of yam flour which will guide food manufacturer/ processors in yam processing and preservation.

MATERIALS AND METHOD

Research Materials

The research materials include five varieties of yam tubers namely; white yam (*Dioscorea rutundata*), purple yam (*Dioscore alata*), yellow yam (*Dioscorea cayenensis*), three leaves yam (*Dioscorea bulbifera*) and water yam (*Dioscorea alata*), which were obtained from Anambra State Agricultural Development Programme (ANADEP) at harvest moisture content range from 56.8 to 65 % wb.

Drying Equipment

Three different drying methods/ equipment were used for the study. They include an Electric oven dryer of model LOA 1805 Munich Germany; A solar dryer (solar energy Collector) locally fabricated, it was made of metallic box having gross dimensions.

The gross dimensions of the absorber plate are 1.0m long, 0.62 m wide and 0.55 mm thickness with a net surface area of 0.62 m^2. The solar collector was covered with one layer clear glass of 3 mm thickness to reduce the reflection of radiation and heat losses by convection. The solar dryer has capacity of 6.38 m^3 with the collector efficiency of 63.5 % and system thermal efficiency of 46.77 %; and a percentage energy loss of 16.73 %. It was attached with the drying chamber by an air duct which has a cross sectional area of 0.14 m^2 and was oriented to face south (where it will get most sunlight) as it was tilt with an optimum tilt angle. The third dryer is natural sun drying (open Air) open space spread with black nylon (so as to be absorbing heat).

Experimental Procedure

Sample preparation

The yam tubers were washed, hand-peeled and sliced to range of 10 to 15mm thickness. Each variety of the yam tubers after slicing were divided into three sets for use at three different drying methods (oven dryer, sun dryer (open air) and solar dryer) The samples for oven drying was further divided into three for use at three drying temperatures. The sliced yam tubers were generally dried in each case to a constant weight and milled accordingly using laboratory harmer mill. The yam flour was separately kept in moisture resistant/air tight container and was taken to the laboratory for functional and visco-elastic properties tests.

Determination of Wettability

The wettability of the yam flour was determined following the method described by Onwuka [22] as adopted by Nwosu [23]. A gram of each yam flour sample was placed in a neat, dry measuring cylinder (10ml). A finger was placed over the open end, the cylinder was inverted and then clamped at a length of 10cm from beaker surface (600 ml beaker) that contains 500 ml of distilled water. The yam flour in the cylinder was slowly spread on the surface of the water at moderate speed. The time it took for each sample to be entirely wet is measured as its wettability.

Water Absorption Capacity (WAC)

The method as describe by Abey [24] as adopted by Onuegbu, [25]. Each sample was weighed and placed into dry, clean centrifugal tube and both weight noted. 10ml of distilled water was poured into the tube and properly mixed with the flour to make a suspension. It was then centrifuged at speed of 3500 rpm for 15 min. After which the suspension was discarded, then the tube and its content reweighed and noted. The gain in weight is the water absorption capacity of the test sample.

Determination of the swelling power and solubility of the yam flour

The swelling power and the solubility of the yam flour were determined using the method of Leach et al [26] as adopted by Eje [27]. In this method, 1g of yam flour sample was weighed into a 50 ml centrifuge tube and water added to give a total volume of 40 ml.

The tube and its contents were heated for 30mins in water bath at a temperature of 85^0C with constant stirring. The sample was then centrifuged for 15 min with Hermle 2206A centrifuge of 5cm radius at a speed of 2200 rpm (271 x g) after cooling to a room temperature. The supernatant was poured into a glass crucible and the weight of the sediment noted. The supernatant in the glass crucible was evaporated in an oven at 105^0C for 24 hours and the residue weighed. The solubility and swelling power were evaluated thus:

$$\text{Solubility (\%)} = \frac{weight\ of\ residue}{weight\ of\ sample} \times 100 \quad (1)$$

$$\text{Swelling power (\%)} = \frac{weight\ of\ sediment}{Weight\ of\ sample\ (100 - solubility)} \times 100 \quad (2)$$

Determination of water binding capacity (WBC)

The water binding capacity of the yam flour was determined using the method of Sathe and Salunkle [28] as adopted by [27]. In the process, 2g of yam flour sample was dissolved in 40ml of distilled water. The aqueous suspension formed was agitated for 1hours in a water bath, after which it was centrifuged for 10mins using Hermle 2206A centrifuge of 5cm radius at 2200 rpm. The free water was decanted from the wet sample and drained for 10 min. The water binding capacity was evaluated from the expression.

$$\text{WBC (\%)} = \frac{bound\ water}{weight\ of\ sample} \times 100 \quad (3)$$

RESULTS AND DISCUSSION

Table 1: Functional characterization of yam flour under three different drying methods.

Yam varieties	***Drying method***	***Wettability*** *(secs)*	***WAC***	***WBC (%)***	***Solubility %***	***Swelling power***
White yam	*Oven*	*173.22*	*146.11*	*311.4*	*4.82*	*11.92*
	Sun	*181.31*	*143.83*	*324.6*	*5.93*	*11.84*
	Solar	*178.38*	*134.32*	*302.1*	*5.11*	*12.63*
Purple yam	*Oven*	*201.00*	*134.32*	*413.6*	*5.28*	*11.34*
	Sun	*191.08*	*141.46*	*361.3*	*4.99*	*11.82*
	Solar	*151.69*	*145.46*	*393.4*	*4.83*	*11.14*
Three leaves yam	*Oven*	*155.00*	*136.33*	*382.1*	*5.92*	*11.28*
	Sun	*190.20*	*138.11*	*299.1*	*5.66*	*11.98*
	Solar	*138.41*	*129.56*	*273.4*	*5.09*	*12.66*
Water yam	*Oven*	*143.62*	*133.58*	*345.2*	*5.28*	*12.38*
	Sun	*148.91*	*163.21*	*363.2*	*4.48*	*12.34*
	Solar	*182.11*	*153.30*	*339.5*	*5.22*	*12.19*
Yellow yam	*Oven*	*162.37*	*128.34*	*382.6*	*5.21*	*11.68*
	Sun	*153.42*	*138.42*	*389.3*	*5.63*	*11.92*
	Solar	*174.34*	*143.88*	*335.2*	*5.24*	*11.96*

Table 1., presents the functional characteristics of yam flour under three different drying methods. Results of this table revealed that white yam recorded wettability range of 173.22 – 181.31 secs. The purple yam had wettability range of 151.69 – 201 secs. The three leave yam, had wettability range of 138.41 – 190.20 secs. The water yam and yellow yam recorded wettability range of 143.62 – 182.11 secs, and 153.42 – 174.34 secs respectively. The wettability obtained in the yam varieties are within the range of wettability obtained by Bashirat et al. [1]. Furthermore, white yam recorded water absorption capacity (WAC) range of 134.32 – 146.11, while purple yam had WAC range of 134.32 – 145.46; three leave yam, water yam and yellow yam recorded 129.56 – 138.11, 133.58 – 163.21 and 128.34 – 143.88 respectively. This water absorption capacity obtained for the yam varieties are consistence with the findings of Adedeji [29] in his study of physical, functional and sensory properties of yam flour. White yam also recorded water binding capacity of (WBC) range of 302.1 – 324.6 %, while the purple yam, three leave yam, water yam and yellow yam had WAC of 361.3 – 413.6%, 273.4 – 382.1 % , 339.5 – 382.6 % , 273.4 – 382.1% , 339.5 – 382.6% and 335.2 – 389.3 % respectively. In terms of solubility, the white yam had a range of 4.82 – 5.93, purple yam 4.83 – 5.28, three leave yam 5.09 – 5.92, water yam and yellow yam had 4.48 – 5.28 and 5.21 – 5.63 respectively. Then for swallowing power, the white yam, purple yam, three leave yam, water yam and yellow yam respectively recorded 11.84 – 12.63, 11.14 – 11.82, 11.28 – 12.66, 12.19 – 12.38 and 11.68 11.96.The swelling power of the yam varieties is also in agreement with the findings of Adedeji [29]. Though the yam varieties recoded similar values in their functional properties, there is little variation. Three leaves yam recorded the highest water absorption capacity which makes it likely to have least shelf life stability because of the ability of absorbing water from a humid atmosphere [30]). Sittu et al. [15] reported in their work that WAC determines the baking quality. Jackel [16] reported that flour with high WAC would result to soft product that will remain soft for longer period which is a favorable characteristics of final product with improve texture and lower cost. The functional values of the yam flours shows that they can be used as composite flour to wheat in bakery industry. They also showed that they can yield a soft product which can be appealing to consumers.

Table 2: ANOVA of the effect of drying methods on the functional properties of the yam varieties.

Sources of variation	***D.f.***	***SS***	***MS***	***F.C al***	***F. Tab***	
					5%	*1%*
Yam varieties	*4*	*-1247130.7*	*311782.7*	*2.93**	*2.56*	*3.74*
Drying method	*2*	*-1247130.7*	*623565.4*	*5.86***	*3.19*	*5.08*
Functionalparameters	*4*	*5911397.6*	*1477849.4*	*13.89***	*2.56*	*3.74*
Error	*49*	*-5211397.6*	*106355.1*			
Total	*59*	*-1794261.4*				

** Significant at both 1% and 5% level of probability; * Significant at only 5%level of probability.

Table 2 presents the ANOVA of the effect of drying methods on the functional properties of the yam varieties. Results of the analysis showed significant difference at 5% and 1% probability level while the yam varieties did not show any significant different on the functional properties of the yam varieties.

CONCLUSION

Based on the findings from the study, the following conclusion can be made about the study:

1. White yam recorded wettability range of 173.22 – 181.31secs. The purple yam had wettability range of 151.69 – 201 secs. The three leave yam, had wettability range of 138.41 – 190.20 secs. The water yam and yellow yam recorded wettability range of 143.62 – 182.11 secs and 153.42 – 174.34 secs, respectively.
2. White yam recorded water absorption capacity (WAC) range of 134.32 – 146.11, while purple yam had WAC range of 134.32 – 145.46; three leave yam, water yam and yellow yam recorded 129.56 – 138.11, 133.58 – 163.21 and 128.34 – 143.88 respectively.
3. The white yam, purple yam, three leave yam, water yam and yellow yam respectively recorded 11.84 – 12.63, 11.14 – 11.82, 11.28 – 12.66, 12.19 – 12.38 and 11.68 11.96 %.
4. Three leaves yam recorded the highest water absorption capacity which makes it likely to have least shelf life stability because of the ability of absorbing water from a humid atmosphere.

RECOMMENDATION

There are over 600 varieties of yam of which 12 are edible in Africa, over 95 % of these crops are grown in Africa. It is therefore recommend that further researches should be carried out on the other varieties of yams in order to come up with important data that will help the yam processors and food industries to improve and optimize their products and manufacturing process.

There are many other drying methods; It is also recommend that other researchers should embark on trying to use them in carrying out researches on yam drying in other to come up with more options and best yam drying method for processors.

Farmers and processors are advice to consider storing good percentage of yam meant for consumption inform of flour, to prolong shelf life and enhance usage. This will also help in eradication of post-harvest loses.

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UTICAJ METODA SUŠENJA NA FUNKCIONALNE OSOBINE JAM (*Dioscorea* sp.) BRAŠNA

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Sažetak: Uticaj metode sušenja na funkcionalna svojstva pet različitih tipova brašna od Jam (Yam): belog, ljubičastog , žutog, vodenog i tri lišća, proučavan je metodom sušenja u peći i na suncu.

Funkcionalna svojstva su određena metodom odobrenom od AACC.
Rezultati ispitivanja su pokazali da je Beli tip Jam (Yam) ima opseg vlažnosti (WAC) od 173.22 do 181.31 secs, dok je ljubičasti varijetet Jam (Yam) imao opseg vlažnosti od: 151.69 do 201 secs. Tri preostala varijeteta jama, imali su respektivno raspon vlažnosti: 138.41 do 190.20 secs, a vodeni i žuti jam imaju zabeležen opseg vlažnosti od 143.62 do 182.11 secs i od 153.42 do 174.34 secs.

Rezultat istraživanja je takođe pokazao da beli Jam (Yam) beleži kapacitet upijanja vode (bubrenje) (VAC) u opsegu od 134.32 do 146.11 secs, dok je ljubičasti Jam (Yam) imao VAC opseg od 134.32 do 145.46. Napušteni varijeteti ove kulture: vodeni i žuti Jam (Yam) imale su vrednosti: 129.56 do 138.11; 133.58 do 163.21, i 128.34 do 143.88 secs. Pored toga, beli jam, purpurni jam, žuti jam su zabeležili respektivno raspon vlage bubrenja od: 11.84 do12.63; 11.14 do 11.82; 11.28 do 12.66; 12.19 do 12.38 i od 11.68 do 11.96.

Tri tipa brašna od Jam (Yam) kulture ostvarila su najveću sposobnost apsorpcije vode, zbog čega je verovatno da će imati najmanju stabilnost u odnosu na druge zbog sposobnosti apsorpcije vode iz vlažne atmosfere.

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Rezultati analize varijanse (ANOVA) o uticaju metoda sušenja na funkcionalna svojstva različitih varijeteta kulture Jam (Yam) pokazali su značajnu razliku na nivou verovatnoće od 5% i 1%, dok varijeteti kulture Jam (Yam) nisu pokazale značajne razlike u funkcionalnim svojstvima varijeteta brašna.

Ključne reči: *metoda sušenja, funkcionalna svojstva, brašno jam, sposobnost kvašenja, apsorpcioni kapacitet.*

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EFFECT OF SOIL TYPE ON POWER AND ENERGY REQUIREMENTS OF SOME SELECTED AGRICULTURAL FIELD MACHINERY IN SOUTH – EAST NIGERIA

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Abstract: The effect of soil type on power and energy requirements of some selected agricultural field machinery (plough, harrow, ridger, rotovator and planter) in south – east Nigeria were studied to enable farmers and users of the equipment select and match appropriately the size of implements and speed of operation to machine (tractor) size to improve the field capacitive performance of the machines based on soil types (clay – loam, loamy – sandy, and sandy – clay soil) in the study area. Results showed that plough recorded the highest fuel (energy) consumption rate of 21.60 l/ha to24.67 l/ha, followed by harrow with fuel consumption rate of 17.21 to 21.66 l/ha, rotovator (15.22 to 19.72 l/ha) and least was planter with fuel consumption rate range from 14.42 to 15.62 l/ha. The highest fuel consumption was recorded on clay-loam soil, followed by sandy-clay and least was on loamy-sandy soil. The plough also had the highest draft force (10.8 kN/m), followed by the harrow and ridger with equal draft force of 10.5 kN/m, planter (8.4 kN/m) and the least was the rotovator with draft force of 5.1 kN/m. Furthermore, the plough gave the highest wheel slippage (15.7 %) followed by harrow (13.3 %), rotovator and planter with equal value of wheel slippage (12.8 %) and least was ridger with wheel slippage of 12.4 %. Sandy-clay soil recorded the highest tyre slippage for all the implements, followed by loamy-sandy and the least tyre slippage was recorded on clay-loam soil. However, all the implements in different soils corded average wheel slippage below the top limit of wheel slippage (20 %), showing that the soils were trafficability.

Key words*: Capacitive performance, energy, famers, field machinery, power, soil type*

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INTRODUCTION

Energy is significant indicator in farm operations. According to Updhyaya et al [1] it plays important role in different land tillage operations, seed planting operation, application of fertilizers, pest/weed controls harvesting of crops etc. Therefore, fuel cost of tillage and/or agricultural productivities should be effortlessly kept at a reduced level to ensure that no amount of operation will lead to high operation cost per hour or keep the cost at a prohibitive level. Thus, machinery operation should be simple and cheap, consistent and low in fuel consumption [2]. Bukhari and Baloch [3], observed that operation speed, implement effective working width and cutting depth, soil type/conditions and operator’s skill of operation influence fuel (energy) consumption rate. It therefore, means that size of implement and speed of operation should be matched to machine size to improve the field capacitive performance of the machine [4].

The major operations that are necessary in agricultural operation are mechanical land clearing, land preparation, seed planting, weeding, fertilizer application and harvesting. These are achieved by effective utilization and management of tractors and their coupled implements. Efficient machinery utilization and/ or management needs accurate performance, power and energy requirement data on the capabilities of the individual machines to achieve a given work schedule and to obtain a balanced mechanization system by matching the performance of different farm equipment. The variation in agro-ecological soil condition requires the knowledge of the energy and power requirements of the coupled implements. Producers of these machines do not make the data available for the farmers in Nigeria; it should have been a better guide in the selection of the implements based on the soil differences applicable in various agricultural regions in Nigeria [5].

Today’s competitive agricultural market demands better utilization/ management of resources and minimization of operating costs so as to optimize production and increase profits. One of the major costs of any agricultural production system is machinery cost. Increasing the performance efficiency of farm machinery may lead to a serious cost reduction. Farmers like other business ventures strive to cover up their expenditures in addition to the cost of the machinery and this is why Yohanna and Ifem [6] noted that an intelligent and well experienced farmer tries to make proper use of farm inputs (seeds, fertilizers, herbicides or insecticides, irrigation water and farm equipment) so as to reduce cost. In Nigeria farm mechanization technology has continually been import-oriented. Agricultural machines and equipment are imported from different countries into Nigeria to aid the different farm mechanization decisions of the government [7]. Presently, the cost of importation of agricultural machinery has been sky rocketed due to the devaluation of the local currency, and to operate within such a bad economic condition, machinery managers, owners and/or users must be careful in selecting and purchasing new machinery. It is therefore necessary that the users should know how a machine performs a given task and the ease and/or rate with which it does the work without failure or breakdown and at minimal wastage of energy.

Huge amount of money is invested by farmers annually in purchasing/hiring, operation, maintenance and management of agricultural field machinery. Most of these machines breakdown/fail unnecessarily during operation, in addition to high energy and power losses incurred in operation due to improper selection of machinery that suit the soil condition and/or mismatching of the implements with the prime mover.

Knowledge of the energy and power unit of the machines will effortlessly ameliorate the plight of farmers, and help them to improve and optimize their production when they make better selection of machines that will match their soil type/conditions.

The aim of this study is to determine the energy and power requirements of some selected agricultural field machinery in South-East Nigeria. This is to obtain data on their fuel consumption rate and power units needed for their operation based on soil type which will guide farmers in machine selection to reduce cost, energy loss, and failure/breakdown and increase their production.

MATERIAL AND METHODS

Description of Experimental Site

The experiment was conducted at five different locations, where the dominant soils (clay-loam, loamy-sandy and sandy- clay soil) in the study area are located, These locations include: demonstration farm of veterinary school, Ezzangbo, OhaukWu L. G. A. Ebonyi State; demonstration farm of department of Agricultural and Bio-Resources Engineering, college of Engineering and Engineering Technology, Michael, Okpara University of Agriculture, Umudike, Abia State; demonstration farm of Department of Agricultural and Bio-Resources Engineering, faculty of Engineering, Nnamdi Azikiwe University, Anambra State; demonstration farm of department of Agriculture, Federal College of Education Ehamufu, Enugu State and in Achara Ubo Ubowalla Emekuku, Oweri North L.G.A., Imo state. The soil in the first and second locations is clay-loam, in the third location the soil is loamy-sandy while in the fourth and fifth locations the soil was sandy- clay.

The tests was conducted in May, through June, July, August, September and October, which coincide with planting season of the year; and which also offer the tractor and the coupled implements an exposure to wide range of soil conditions.

Prior to the field operation test, the soil physical properties such as moisture content, bulk density, porosity and texture which influence energy and power consumption rate of the implements were determined in the various sites used for the study.

Description of Machine Used for the Test

A Massey Ferguson tractor of model MF430E and capacity 55.2 kW, with 3- point hitch systems and age of 5months from date of first hand purchase was hired and used for the study. The hitched implements that were studied include ploughs, harrows, rotovators, ridgers, and planters.

Field Operation Test

The field operations such as ploughing, harrowing, ridging, pulverization and sowing were generally performed longitudinally with the implement full width at selected forward speeds and cutting depth, the distance travelled and the corresponding time taken to complete the working distance were noted; and the energy and power requirements of the various implements were determined as stated below.

Measurement of Fuel Consumption

A graduated cylindrical container was used to measure the amount of fuel required to refill the fuel tank of the tractor immediately after each operation as used by Udo and Akubuo [2]. This measurement provided the quantity of fuel consumed during each experiment. The fuel consumption rates was calculated in liter/ha and liter/hr as suggested by Alnahas [8].

$$\text{Rate of consumption (l/ha)} = \frac{Reading\ of\ cylinder, litres}{Area\ of\ land\ covered, hacters} \quad (1)$$

$$\text{Rate of consumption (l/h)} = \frac{Reading\ of\ cylinder, litres}{Time\ taken\ to\ coverthe\ land\ area, hours} \quad (2)$$

Determination of Power requirement of the implements

Draft Force

Draft can be evaluated due to drawbar power (it is the power, in relation to pull-type or mounted implements, actually required to pull or move the implement at uniform speed) by the following equation [9]:-

$$D = \frac{C \times DBP}{S} \quad (3)$$

Where:
D = draft, kN
C = constant, 3.6
DBP = drawbar power, [kW],
S = travel speed, km^{-1}.

Drawbar Power

This is the power transferred through the drive wheels or tracks to move the tractor and implement It was evaluated from equation 2 according to Hunt [10].

$$\text{Drawbar power} = \frac{total\ draft,\ (kN) \times speed\ km^{-1}}{36} \quad (4)$$

Slippage (Travel reduction)

According to Ani et al. [11] the tyre slippage is estimated from the following formula

$$\text{Tyre slip} = \frac{Va}{Vt} \quad (5)$$

Where is:
Va = speed of tractor when implement is engage (under load), km
Vt = speed of tractor when implement is disengaged (no load), km

RESULT AND DISCUSION

Table 1. Effect of soil type on Fuel consumption rate at different soil type/ conditions

Quantity of fuel consumed									
	Ploughing			*Harrowing*			*Ridging*		
Soil type	*l/ha*	*l/hr*	*MC. w.b*	*l/ha*	*l/hr*	*MC. w.b*	*l/ha*	*l/hr*	*MC. w.b*
Clay-loam	*24.24*	*9.57*	*16.18*	*21.15*	*8.54*	*15.52*	*21.08*	*8.84*	*14.35*
Loam-sandy	*21.46*	*8.59*	*15.70*	*18.26*	*7.45*	*14.37*	*18.04*	*7.60*	*14.08*
Sandy-clay	*22.29*	*8.50*	*16.47*	*19.29*	*8.14*	*16.39*	*19.14*	*8.07*	*15.18*

Soil type	*Rotovator*			*Planting*		
	l/ha	*l/hr*	*MC.w.b*	*l/ha*	*l/hr*	*MC.w.b*
Clay-loam	*18.96*	*8.12*	*14.07*	*15.07*	*6.28*	*13.54*
Loam-sandy	*15.25*	*6.50*	*13.51*	*14.92*	*6.20*	*14.32*
Sandy-clay	*16.15*	*6.95*	*14.76*	*15.30*	*6.30*	*14.54*

Results of Table 1., indicates that ploughing recorded the highest average fuel consumption rate 24.24 l/hain clay-loam soil, 22.29 l/ha in sandy-clay, and 21.29 l/ha in loamy-sandy soil. This is closely followed by harrowing operation with fuel consumption rate of 21.15 l/ha in clay-loam, 19.29 l/ha in sandy-clay and 18.26 l/ha in loamy-sandy soil. This is also followed by ridging with average fuel consumption rate of 21.08 l/ha in clay-loam, 19.14 l/ha in sandy-clay and 18.04 l/ha in loamy-sandy soil; rotovator with consumption rate of 18.96 l/ha in clay-loam, 16.15 in sandy-clay and 15.25 l/ha in loamy-sandy soil. The least average fuel consumption rate was recorded by planter planter with fuel consumption rate of 6.30 l/ha, 6.28 l/ha and 6.20 l/ha in sandy-clay, clay-loam and loamy-sandy soil, respectively. The highest fuel consumption rate of the plough as compared to other implements is due to high tractive and draft force associated with its operation [12].

Table 2: Effect of soil type on implement power requirements under different soil conditions

Soil type (M.C.% w.b)	*Implement power requirements*									
	Plough		*Harrow*		*Ridger*		*Rotovator*		*Planter*	
	Dp	*Db*	*Dp*	*Db*	*D p*	*Db*	*Dp*	*Db*	*Dp*	*Db*
Clay-loam (13.23 -17.12	*10.8*	*18.6*	*10.5*	*17.1*	*10.5*	*18.1*	*5.1*	*8.8*	*8.8*	*13.8*
Loamy-sandy (13.53 -16.20)	*10.8*	*18.1*	*10.5*	*20.2*	*10.5*	*20.5*	*5.1*	*9.2*	*8.4*	*15.7*
Sandy-clay 16.21 – 18.63)	*10.8*	*19.6*	*10.5*	*18.9*	*10.5*	*19.1*	*5.1*	*9.4*	*8.4*	*15.4*
Mean	***10.8***	***18.8***	***10.5***	***18.7***	***10.5***	***19.2***	***5.1***	***9.1***	***8.4***	***15.0***

Dp =Draft power (kN); Db = Drawbar power (kW)

Results of Table 2 revealed that each tractor–hitched implement irrespective of soil type and condition had constant draft force. Ploughing recorded the highest constant draft force of 10.8kN; followed by the harrow and ridger with the same draft force of 10.5 kN respectively, planter (8.4 kN) and rotovator has least draft force of 5.1 kN.

In the case of drawbar power, plough recorded average of 18.6 kW, 18.1 and 19.6 kW power respectively in clay-loam soil, loamy - sandy and sandy- clay soil. In the same other harrow recorded 17.1 kW, 20.2 kW and 18.9 kW respectively.
The ridger had 18.1 kW in clay-loam soil, 20.5 kW power in loamy-sandy soil and 19.1 kW power in sandy-clay soil while the rotovator had 8.8 kW, 9.2 kW and 9.4 kW on clay-loam, loamy-sandy and in sandy-clay soil respectively and finally, the planter operated with drawbar power of 13.8 kW on clay-loam soil,15.7 and 15.4 kW on loamy-sandy and sandy- clay soil respectively. It was generally observed that the plough, harrow and ridger were operated with higher drawbar forces as compared to the rotovator and planter. This may be due to the fact that seeding and rotovator operation do not require much tractive or drawbar power for their operations.

Table 3. Effect of soil type on implement power losses under different soil conditions

Soil type	*Implement power loss*				
	Plough	*Harrow*	*Ridger*	*Rotovator*	*Planter*
Clay – loam (13.23-17.13	*15.8*	*13.4*	*12.6*	*12.9*	*12.8*
Loamy–sandy (13.53-16.20)	*12.8*	*11.7*	*11.1*	*11.6*	*11.4*
Sandy – clay (16.21- 18.63)	*18.6*	*14.8*	*13.6*	*13.9*	*14.2*
Mean	*15.7*	*13.3*	*12.4*	*12.8*	*12.8*

Table 3 showed that the plough gave the highest tyre slippage for all the soils. It recorded 15.8 % on clay-loam soil at moisture content range of 13.23 – 17.12 % (w.b), 12.8 % on loamy-sandy soil (moisture content of 13.53 – 16.20 % (w.b) and 18.6 % on sandy- clay soil (moisture content of 16.21 – 18.63 % (w.b). This was followed by the harrow with average tyre slippage of 13.4 % on clay-loam, 11.7 % on loamy-sandy and 14.8 % on sandy-clay soil; the rotovator had average slippage of 12.9 % on clay-loam, 11.6 % on loamy-sandy and 13.9 % 0n sandy-clay soil while the planter recorded 12.8, 11.4 and 14.2 % on clay-loam, loamy-sandy and sandy-clay soil respectively. The least tyre slippage was recorded by the ridger with average tyre slippage of 12.6 % on clay-loam, 11.2 % and 13.6 % on loamy-sandy and sandy- clay respectively.

For all the soils studied, the sandy-clay soil gave the highest tyre slippage for all the implements followed by the clay-loam and the least slippage was encountered on the loamy-sandy soil. This may be as a result of high moisture content observed in sandy-clay soil than the other soils making it to be softer with more deforming effect than the other soils. However, results obtained broadly revealed that the average percentage of tyre slippage of all the implements in different soils are below the top limit of wheel slippage of 20 % as recorded by Pensson et al [13] and also as observed by Alnahas [8].

CONCLUSION

The following conclusion can be made about the study:

1. Ploughing recorded the highest fuel consumption rate of 21.60 l/ha to 24.67 l/ha, followed by harrow (17.21 to 21.66 l/ha), rotovator (15.22 to 19.72 l/ha), and least is the planter with fuel consumption rate range from 14.42 to 15.62 l/ha.
2. The highest fuel consumption was recorded when working on clay-loam soil, followed by sandy-clay and least was on loamy-sandy soil. The variation is due to the high draft force needed to break the high soil compaction in the higher bulk density soil locations than the lower bulk density areas.
3. The plough has the highest draft force (10.8 kN/m), followed by the harrow and ridger with the same draft force of 10.5 kN/m) and the least was the planter with draft force of 5.1 kN/m. The high draft force of the plough is the reason for its high fuel consumption rate.
4. All the implements in different soils recorded average wheel slippage below the top limit of wheel slippage (20 %), showing the soils are trafficability.
5. Sandy-clay soil recorded the highest tyre slippage for all the implements, followed by loamy-sandy and the least tyre slippage was recorded on clay-loam soil.
6. Ploughing gave the highest wheel slippage (15.5 %) followed by harrow (13.1 %), rotovator (12.7 %), planter (12.6 %) and least was ridger (12.6 %).

RECOMMENDATIONS

Results of this study form a database that will guide the farmers and agriculturists in selecting farm machineries/implements that will suit the soil conditions in south-east agricultural zone and other agricultural areas with similar soil and ecological conditions.

Differences exist in soil conditions among different agricultural or ecological areas; it is therefore recommended that more studies should be conducted in every agricultural zone to provide data on machine/ implement power and energy requirements based on soil conditions for increased production, minimize production costs, reduce loss/wastage of energy, time and waste of agricultural products.

Finally, this study did not cover all the agricultural field machineries. Researchers are also recommended to make detailed time study in other machineries not covered in this work in other to provide database in their power and energy requirements as to guide farmers here and other agricultural zones in machine/implement selections.

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UTICAJ TIPA ZEMLJIŠTA NA ENERGETSKE ZAHTEVE NEKIH ODABRANIH POLJOPRIVREDNIH MAŠINA U JUGOISTOČNOJ NIGERIJI

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Sažetak: Proučavan je uticaj tipa zemljišta na energetske potrebe nekih odabranih poljoprivrednih mašina (plug, drljača, rotofreza i sejalica) u jugoistočnoj Nigeriji, kako bi se poljoprivrednicima i korisnicima opreme omogućilo da odaberu i na odgovarajući način odgovore veličini opreme i brzini rada za poboljšanje kapaciteta polja na mašinama na osnovu tipova zemljišta (glina - ilovača, ilovasto - peskovito i peskovito – glinoviti tip) na istraživanom području.
Rezultati pokazuju da je plug imao najveću potrošnju goriva (energije) od 21,60 l /ha do 24,67 l/ha, zatim drljača sa potrošnjom goriva od 17,21 do 21,66 l/ha, rotofreza od 15,22 do 19,72 l/ha. Najmanja potrošnja je bila kod sadilica sa opsegom potrošnje goriva od 14,42 do 15,62 l/ha.

Najveća potrošnja goriva zabeležena je na glinovito-ilovastim tipovima zemljišta, a zatim na peskovito-glinovitom i najmanje na glinovito-peskovitim tipovima zemljišta.

Plug ima najveću silu vuče od 10.8 kN/ m, zatim drljača od 10.5 kN/m, pa sadilica od 8.4 kN / m. Najmanja sila vuče je kod rotofreze od 5.1 kN/m.

Osim toga, plug je prouzrokovao najveće proklizavanje točkova (15,7%), zatim drljača (13,3%). Rotofreza i sadilica imaju jednake vrednosti proklizavanja točkova (pneumatika) (12,8%). Najmanja vrednost klizanja točkova je kod kultivatora od 12,4%.

Peskovito-glinoviti tip zemljišta je imao najveće klizanje pneumatika za sva oruđa, a najmanje klizanje točkova je zabeleženo na zemljištu tipa ilovača.

Međutim, svi priključci na različitim zemljištima imaju prosečno proklizavanje točkova ispod gornje granice klizavanja točkova od 20%, što pokazuje da su ovakva zemljišta pogodna za kretanje mašina.

Ključne reči: *Performanse, učinak, energija, farmeri, terenske mašine, snaga, tip zemljišta*

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EVALUATION OF THE CAUSES OF EROSION AND SOLUTION: CASE STUDY UMUOKORO LOWA, IHITTE/UBOMA LOCAL GOVERNMENT AREA, IMO STATE

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Abstract: Erosion is a condition in which the surface of the earth declines gradually due to wearing away by the action of water, wind and human activities. This research was carried out to determine the types of erosion occurring in this area and provide proper erosion management techniques that will help to control the erosions occurring in this area. Erosion control techniques are used to prevent and reduce soil erosion. Visual examination, interviews from residents and measurement of measurement of the erosion to know the cause, nature and type of erosion at the sites were carried out. Results of visual examination and interviews revealed that the erosion was caused by abandoned road construction and poor land management practices of the residents. Measurements from site A, D and G at the month of May which were 0.28, 0.29 and 0.29 m in depth respectively showed that they have already degenerated from splash to rill and is gradually forming gully, while site B and C at the month of May which were 1.53 and 2.34 m in depth respectively were still active gullies. Site F and G have already degenerated from rill to gully and will be worse if nothing is done on time. Implementation of the solutions recommended like regarding and tarring the roads, planting vegetative covers and proper sensitization of the villagers is necessary to improve and maintain the environment.

Keywords: *Erosion, Earth, Human Activities, Gully, Solutions.*

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INTRODUCTION

Soil is a dynamic natural body on the surface of the earth in which plants grow, it is composed of minerals and organic materials and living forms [1]. Soil is a key element to agriculture without it, we won't be able to grow plants, which are used as food for both humans and animals.

In general, farmers lose a large amount of the top soil each year which is estimated to about 24 billion tones to erosion in developing countries. Erosion rate per acre are twice as high as the standard partly because population pressure forces land to be more intensively farmed [2]. Soil erosion refers to the removal of soil materials from their original location and their subsequent transport to another location through the action of wind, water, ice, biotic processes, or human activities [3]. The level of soil destruction differs in different parts of the country, depending on the cause of the erosion [4, 5, 6]. Erosion leads to loss of land for agriculture, resulting to reduction in annual crop yield. Soil erosion may be induced naturally or artificially, meanwhile, the natural occurrence poses more environmental hazards [7]. According to [8, 9], erosion of the soil occurs in four major stages, which are; detachment by rain drop impact; transport by raindrop impact (splash erosion); detachment by the shearing forces of flowing water and transport in surface runoff (sheet erosion, rill and gully erosion). Gully erosion is the most destructive type of erosion, which is characterized with ephemeral flow, large channel which may reach or more than 0.3m and 0.6m in width and depth respectively [10]. Erosion is a serious problem for agricultural production as it has greatly affected agricultural productive lands. Reduction in yield of up to 50% has been documented on severely eroded soils in many parts of the world [11]. The crops grown in this areas have poor nutrients and provides poor nourishment to individuals that consumes them.

Excessive and accelerated erosion cause both “on site” and “off-site” problems, like decrease in agricultural productivity, sedimentation of water ways, eutrophication of water bodies, damage to roads and houses. Erosion must be kept to acceptable limits in accordance to [12]. However, Vegetation growth in regions with regular rainfall could be a preventive measure for erosion [13]. There are various materials used as preventive measures in controlling erosion. Some of the common materials are limestone, granite, vegetation, staked perforated plastic sheet, coconut fiber, straw, steel wire mesh cage. There are techniques similar to natural method of protecting the soil that is employed in preventing erosion. These include conservation practices which positively affect major erosion and sedimentation and thus, reduce sediment movement in one or more ways. These techniques include: absorbing rain drop impact energy, absorbing run off, slowing run-off scour forces, and prevention of soil massive movement [14]. Also, there are other methods that are used in erosion control, with some listed viz-a-viz, reforestation, riprap, gabions, buffer strip, sand fence, fiber rolls, erosion control blankets, and provision of water channels to divert water and eliminate flooding.

Erosion is a major problem experienced annually in Umuokoro Lowa village, Ihitte/Uboma local government area, Imo state. The adverse effect of erosion in this area has hindered development in the community. There are some techniques that have been applied in the community like the use of sand bags, which are not effective to tackle soil erosion. Therefore, there is need to investigate on the causes of erosion in the area and proffer adequate solution that can help Umuokoro Lowa village, in Ihitte/Uboma local government area of Imo State in restoring the affected sites in the community.

To achieve this target, there was identification and evaluation of the various types of erosions that are predominant in the village, identification of the efficiency of the various types of erosion control measures that already exists, and proffered possible solutions with adequate preventive measures for the affected areas. Soil plays an important and integral role in our everyday life that supplies our foods, support our houses and highway and acts as building materials.
The research is targeted to solving a problem of erosion by investigating the causes, effects and proffer solutions to erosion based on the findings. This research work would be of importance and have benefits to the country by reducing the alarming rate of environmental dilapidation through soil loss. The research will help to create awareness on the types and causes of erosion and the dangers attached if it is not arrested on time. It will also provide information to prevent erosion occurrence by providing erosion control measures that would help to checkmate the menace in future.

MATERIALS AND METHOD

Description of The Study Area

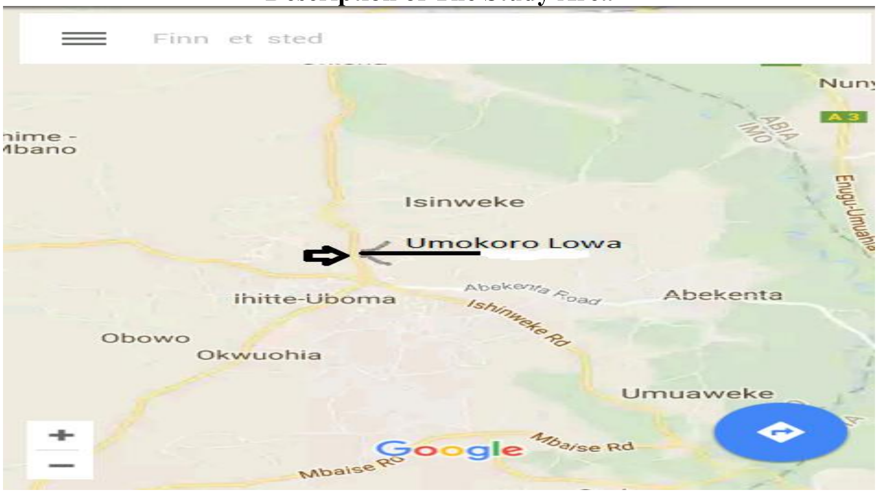

Figure 1: Umuokoro Lowa village, [15]

Umuokoro Lowa is a village in Okata community in Ihitte/Uboma Local Government Area of Imo state, Nigeria. It can be located on latitude 5^0 37’ 18’’N and longitude $7^0$21’ 54.9’’E. The climatic region is in the rain forest zone of Nigeria. The climate is characterized by two seasons, which are the rainy season and the dry season. The rainy season starts from April and end in September while the dry season starts from October and ends in March. Although, there are some times when there may be change in atmospheric condition, like this year that the rainy season started early at February. The village has a sloppy landscape which makes it prone to erosion.

Materials and Their Usefulness

The materials used in this research work are (i) Field record book (ii) Pen (iii) Surveyor's Tape (iv) Carpenters Tape (v) Camera. Field Record Book was used to record the readings from the measurement of the erosion areas. Pen was used in writing down the readings. Surveyor's tape was used in taking measurements which are the length, width, and depth of the eroded areas. Carpenters tape was used in taking short distance measurements of the eroded areas. Camera was used in the reconnaissance stage to take pictures of the locations.

Methods

This research work was carried out in two stages: (1) The reconnaissance stage/survey (2) investigation of the erosion in the area.

Reconnaissance Stage/Survey

The field inspection was carried out randomly to locate the erosion areas by taking necessary photographs of the affected sites in Umuokoro Lowa.

Investigation of the Erosion Area

The survey of the erosion areas was carried out through visual examination and measurement of the erosion characteristics which are length, width and depth to ascertain the nature and types of erosion occurring in the area. The work was done using 30m surveyors tape to take long distance measurements and 12m carpenters tape in taking short distance measurements. The readings were tabulated and the erosion types identified from the size of their depth according to readings from literatures. They were: Length (It was measured to determine the distance of the erosion); Width (It was measured to determine the wideness of the erosion); Depth (It was measured to determine how deep the erosion have gone and also to know the type of erosion occurring in the place); Nature of the erosion (This was to know the state of the erosion whether still active or not). In terms of Classification, the erosion type was classified based on the depth of incision as cropped from standard literature. Sheet: 0 cm - 4 cm; Rill: 5cm ---30cm; Gully: 40cm and above. [16, 17].

RESULTS AND DISCUSSION

Description of Site A

Plate 1: Erosion at site A

Table 1: Observation at site A

Month	Length (m)		Width (m)		Depth(m)		Nature
	X	Y	X	Y	X	Y	
March	9.3	9.8	0.99	1.14	0.14	0.17	Rill
April	9.8	10.2	1.14	1.24	0.17	0.23	Rill
May	10.4	11.1	1.27	1.35	0.23	0.28	Rill

X = dimension before rainfall, Y= dimension after rainfall

Causes and Evaluation of Erosion at Site A

The road was only graded and was not tarred, a graded road is prone to erosion because it is similar to a bare ground that does not have cover it should be tarred hence, the road graduated from splash to sheet then to rill. If care is not taken it will graduate to gully erosion. From the report gotten from the residents, it was observed that this site was not too bad until the time it was graded for construction.

Proffered Solution to Site A

The road should be re-awarded for finishing work and it should be completed by grading the road and ensure that is tarred and it must be reconstructed with side drains both at the left and right sides of the road. The work of the side drains is to transport water during rainfall from the road to the bushes. In addition mitre drain should be constructed with the side drain because sometimes the rainfall intensity and long duration of rain will make the side drains to be overflowed. Therefore, mitre drain is constructed along the side drain at 20 to 25 meter range. The work of the mitre drain is to divert excess runoff into the bush and prevent the road from been damaged by flood.

Description of Site B

Plate 2: Erosion at site B

Table 2: Observation at site B

Month	Length (m)		Width (m)		Depth (m)		Nature
	X	Y	X	Y	X	Y	
March	13.37	13.45	0.98	1.12	0.94	0.99	Gully
April	13.45	13.56	1.12	1.20	0.99	1.3	Gully
May	14.06	15.00	1.26	1.32	1.39	1.53	Gully

X = dimension before rainfall, Y= dimension after rainfall

Causes and Evaluation of Erosion at Site B

From plate 2, it can be observed that the rate of runoff in this area is very high as it has already carried away the sand bags used in checking it. The water coming into the gully from different runoff sources has high erosive effect on the soil, because the interceptor ditches used in intercepting them where removed in the cause of abandoned road construction. From residents' point of view, it was observed that erosion in this site was aggravated due to human activities like soil excavation and improper refuse disposal thereby blocking the runoff channel. It was also observed that the removal of the interception channels also led to the increase in runoff passing through the area.

Proffered Solution to Site B

The runoff sources should be traced first and vegetative covers like grasses should be planted within the runoff sources to reduce the velocity of water flowing into the gully site. It can also be controlled by building a silt fence with gravel bags which will trap sediments that will fill the gully and allow easy passage of water through the pores of the bag. Reconstruction of interceptor ditches should be properly done so that runoff will be intercepted and prevented from coming down to this site.

Description of Site C

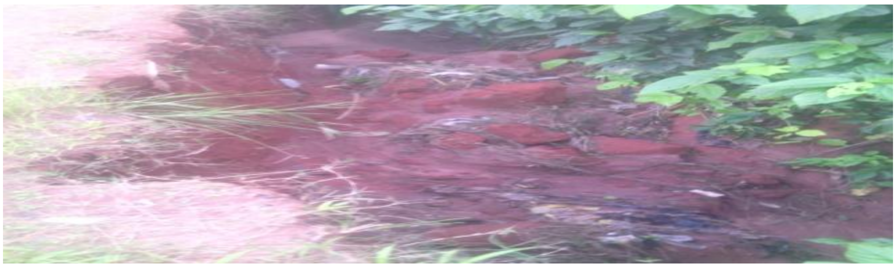

Plate 3: Erosion at site C

Table3: Observation at site C

Month	Length (m)		Width (m)		Depth (m)		Nature (m)
	X	Y	X	Y	X	Y	
March	8.6	9.0	3.0	3.29	1.7	2.0	Gully
April	9.0	9.4	3.29	3.4	2.0	2.17	Gully
May	9.46	10.7	3.45	4.0	2.26	2.34	Gully

X = dimension before rainfall., Y= dimension after rainfall

Causes and Evaluation of Erosion at Site C

From the plate 3 and response gotten the residents, it was observed that the gully occurring in this area is still very active. This site is a natural runoff channel but has been destroyed and exposed to erosion due to constant sand excavation that goes on there at the end of every rainfall. This has led to the softening of the soil allowing it to be easily washed off by runoff water.

Proffered Solution to Site C

The type of erosion occurring in this area is gully erosion. This type of erosion can be controlled firstly by tracing the runoff sources and reducing the speed through planting vegetative covers which will help reduce the velocity of the runoff that is passing through this channel. It can also be controlled by the use of Gabions, the gabions are made of a porous structure that is made of heavy duty wire netting that is filled with stones which will make for easy passage of water and allow sediment concentration that will help the area to recover its lost soil. Terraces can also help in controlling the amount of runoff that goes into the by diverting the runoff into other channels.

Finally, laws should also be enacted to control the human activities that contribute to the erosion problem.

Description of Site D

Plate 4: Erosion at site D

Table 4: Observation at site D

Month	Length (m)		Width (m)		Depth (m)		Nature (m)
	X	Y	X	Y	X	Y	
March	29.65	29,83	0.86	0.92	0.14	0.18	Rill
April	29.83	30.9	0.92	1.24	0.18	0.22	Rill
May	32.32	34.0	1.28	1.36	0.24	0.29	Rill

X = dimension before rainfall. Y= dimension after rainfall

Causes and Evaluation of Erosion at Site D

This area is sloppy in nature and is barred of vegetative covers and drainage passage, this makes it easy for raindrops and erosive water to move freely on the land surface with high velocity causing the soil to be detached and carried away. From residents response there was vegetative covers in this area before the road was graded.

Proffered Solution to Site D

The type of erosion occurring in this area is rill. This can be controlled by the following ways: Drainage ways should be constructed at both sides of the road, the runoff sources should be traced and the runoff water diverted into the constructed drainages by creating channels that will help carry the runoff water into the drainages or by laying underground pipes that will carry the water. This will reduce the amount of water that will flow down the slope without having effect on the soil. Secondly, vegetative covers should be planted; this will help absorb the impact of raindrops and runoff velocity on the soil surface by increasing infiltration rate.

Also, a semi-permeable synthetic ground cover(fabric) can be laid on the slope add stability, it will slow the water flow and allow it to be absorbed by the soil, as well as keeping the water from washing the soil away. Finally, the road should be graded and asphalted with drainage structures or ditches constructed at both sides of the road this will eradicate the erosion at this site for a long period of time.

Description of Site E

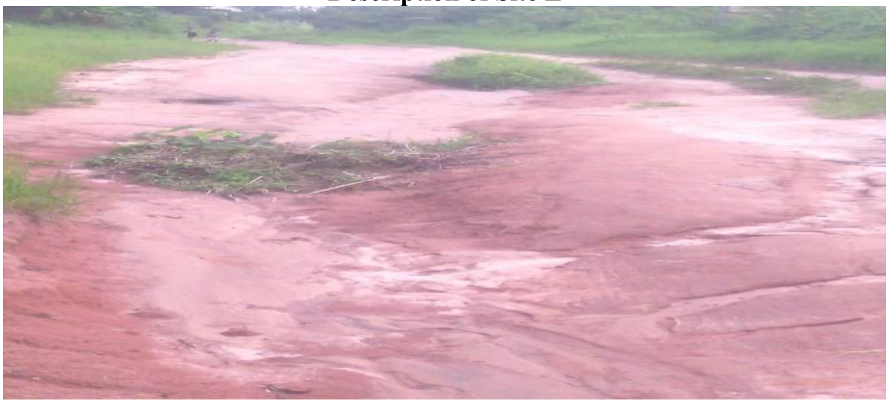

Plate 5: Erosion at site E

Table 5: Observation at site E

Month	*Length (m)*		*Width (m)*		*Depth (m)*		*Nature (m)*
	X	*Y*	*X*	*Y*	*X*	*Y*	
March	*29.45*	*30.9*	*1.35*	*1.43*	*0.21*	*0.27*	*Rill*
April	*30.9*	*32.0*	*1.35*	*1.43*	*0.27*	*0.33*	*Gully*
May	*33.0*	*34.0*	*1.48*	*2.02*	*0.37*	*0.43*	*Gully*

X = dimension before rainfall, Y= dimension after rainfall

Causes and Evaluation of Erosion At Site E

From the plate 5 it can be observed that the rate of runoff flow is too high in this area and the land is barred of vegetative covers that will reduce the speed of the runoff thereby causing it break and carry away the soil particles easily. Responses from the residents showed that the removal of drainage channels that were in this area due to construction led to the occurrence of erosion.

Proffered Solution to Site E

The type of erosion occurring in this site is gully. To get this area under control, the sources of erosion should be tackled first. These sources can be tackled by reducing the runoff speed so that the rate of erosion occurring at site E will be reduced. The runoff sources can be reduced by planting grasses and trees that can thrive in the environment. Channels should be created by the sides of the road to divert the excess runoff that the adjacent side of the road. The eroded portions should be mulched before grading or filled with stones to enable it trap sediments and reduce the rate of scouring and soil loss.

If the road can be graded and asphalted with drainage channels at both sides of the road, it will be the best solution in solving the erosion menace at this site.

Description of Site F

Plate 6: Erosion at site F

Table 6: Observation at site F

Month	Length (m)		Width (m)		Depth (m)		Nature (m)
	X	Y	X	Y	X	Y	
March	27.56	28.70	1.27	1.38	0.22	0.26	Rill
April	28.70	29.82	1.38	1.43	0.26	0.29	Rill
May	31.64	33.56	1.69	1.93	0.32	0.34	Gully

X = dimension before rainfall, Y= dimension after rainfall

Causes and Evaluation of Erosion at Site F

The land management practice in this area is very poor as the drainage channels has been covered with sediments and bushes there by, causing runoff water to flow through the road and cause erosion since the soil in the area is no longer compactable to accommodate the flow without been washed away.

Proffered Solution to Site F

The type of erosion occurring in this area is gully. This type of erosion can be reduced by first clearing the drainage channels so that runoff water can flow freely without been obstructed. Terraces can also be built to divert excess runoff away from the road.

Description of Site G

Plate 7: Erosion at site G

Table 7: Observation at site G

Month	*Length (m)*		*Width (m)*		*Depth (m)*		*Nature (m)*
	X	*Y*	*X*	*Y*	*X*	*Y*	
March	*26.78*	*27.02*	*1.35*	*1.38*	*0.16*	*0.23*	*Rill*
April	*27.02*	*27.54*	*1.38*	*1.45*	*0.23*	*0.26*	*Rill*
May	*28.03*	*28.67*	*1.50*	*1.86*	*0.26*	*0.29*	*Rill*

X = dimension before rainfall., Y= dimension after rainfall

Causes and Evaluation Of Erosion at Site F

The rate of rainfall in this area is very high and the area lacks drainage control channels which make it easy for erosive water to be passing through the road causing the soils to be easily detached and carried away. The resident in this area observed that the erosion started occurring due to the removal of drainage channels and abandonment after grading the area for construction.

Proffered Solution to Site F

Drainage channels should be created at both sides of the road, the road should also be graded and vegetative covers that thrive in the area should be planted too to help reduce raindrop impact and runoff speed.

CONCLUSION

Examinations of the various types of erosion occurring in Umuokoro Lowa, Ihitte/Uboma L.G.A Imo State had been investigated, and solutions that can help manage the menace had been proffered. It was discovered that Site A, D and G have been eroded to a depth of 28, 29 and 29 cm respectively from splash to rill and is gradually forming gully, while site B and C at the month of May which were 1.53 and 2.34 m in depth respectively were still active gullies.

Site F and G have already degenerated from rill to gully and will be worse if nothing is done on time. It was concluded that the rate at which erosion is occurring in the area is at high level and requires quick intervention. It was also observed that the erosions were due to construction and poor maintenance culture by the inhabitants.

In other to prevent impending disaster trying to occur in this area, it is recommended that the solutions and techniques proffered should be put in place without further delay. Government and other agencies charged with the responsibility of protecting the environment should take proactive measures in educating the populace on the adverse effects associated with this menace, proper drainage management system should be in place when designing plans for road construction. Finally, the community should imbibe the culture of proper waste disposal system and avoid practices that will lead to water way blockage.

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EVALUACIJA UZROKA EROZIJE I REŠENJA: STUDIJA SLUČAJA UMUOKORO LOWA, IHITTE/UBOMA LOKALNA UPRAVA, IMO DRŽAVA, NIGERIJA.

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Sažetak: Erozija je stanje u kojem se površina Zemlje postepeno smanjuje zbog odnošenja čestica sa vodom, vetrom ili ljudskim aktivnostima.

Ovo istraživanje je sprovedeno kako bi se utvrdile vrste erozije koje se dešavaju u ovoj oblasti i obezbedile odgovarajuće tehnike upravljanja intenzitetom erozije, koje će pomoći u kontroli procesa erozija koje se dešavaju u ovoj oblasti.

Tehnike kontrole erozije koriste se za sprečavanje i smanjenje erozije zemljišta. Izvršeno je vizuelno ispitivanje, intervjuisanje stanovnika i merenje erozije, da bi se znali uzrok, priroda i vrsta erozije na određenim lokalitetima.

Rezultati vizuelnog pregleda i intervjua pokazali su da je erozija uzrokovana napuštanjem izgradnje/održavanja puteva i lošom praksom upravljanja i upotrebe zemljišta od strane lokalnih stanovnika. Merenja sa lokaliteta A, D i G u mesecu maju, koja su bila 0,28, 0,29 i 0,29 m dubine, pokazala su da već postoje degradacije od padavina i neadekvatne obrade koje postepeno formiraju jarak.

Lokacije B i C u mesecu maju, mereno na 1.53 i 2.34 m dubine, pokazuju još aktivniju pojavu jaraka (erozije) na površini. Lokacije F i G su degradirane obradom do pojave jaruga i biće intenzivnije ako se ništa ne uradi na vreme.

Implementacija rešenja koja se preporučuju, kao što je ravnanje i tanjiranje površine puteva, sadnja vegetacionih pokrivača i pravilna informacija lokalnih stanovnika korisnika ovih površina, neophodna je za poboljšanje i održavanje životne sredine.

Ključne reči: *Erozija, Zemlja, ljudske aktivnosti, jaruga, rešenja*

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