STUDY THE FEASIBILITY OF ZERO-TILL HAPPY SEEDER UNDER DIFFERENT SOIL CONDITIONS OF ANDHRA PRADESH

By

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2022

DECLARATION

I, **Ms. MAHESHWARI,** hereby declare that the thesis entitled **"STUDY THE FEASIBILTY OF ZERO-TILL HAPPY SEEDER UNDER DIFFERENT SOIL CONDITIONS OF ANDHRA PRADESH"** submitted to the **Acharya N.G. Ranga Agricultural University** for the degree of **Master of Technology in Agricultural Engineering** in the major field of **Farm Machinery and Power Engineering** is the result of original research work done by me. I also declare that no material contained in the thesis has been published earlier in any manner.

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CERTIFICATE

Ms. **MAHESHWARI** has satisfactorily prosecuted the course of research and that the thesis entitled **“STUDY THE FEASIBILITY OF ZERO-TILL HAPPY SEEDER UNDER DIFFERENT SOIL CONDITIONS OF ANDHRA PRADESH”** submitted is the result of original research work and is of sufficiently high standard to warrant its presentation to the examination. I also certify that neither the thesis nor its part thereof has been previously submitted by her for a degree of any university.

Date: **CHAIRPERSON**

Place: Bapatla

CERTIFICATE

This is to certify that the thesis entitled **"STUDY THE FEASIBILITY OF ZERO-TILL HAPPY SEEDER UNDER DIFFERENT SOIL CONDITIONS OF ANDHRA PRADESH"** submitted in partial fulfillment of the requirements for the degree of **"Master of Technology in Agricultural Engineering"** in the major field of **"Farm Machinery and Power Engineering"** of the Acharya N. G. Ranga Agricultural University, Lam, Guntur is a record of the bonafide original research work carried out by **Ms. MAHESHWARI** under our guidance and supervision.

No part of the thesis has been submitted by the student for any other degree or diploma. The published part and all assistance received during the course of the investigations have been duly acknowledged by the author of the thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

%	: percent
ANOVA	: Analysis of Variance
BD	: Bulk Density
CA	: Conservation Agriculture
CNC	: Computer numerical control
cm	: centimeter
Co_2	: Carbon dioxide
CRR	: Complete Residue Removal
CH_4	: Methane
C.V	: Coefficient of Variation
DAS	: Days after sowing
et al.	: And others
etc.	: and the rest
Fig.	:Figure
GJ ton^{-1}	: Giga Joule per ton
g/m^2	:Gram per meter square
ha^{-1}:	:per hectare
Hp	: Horsepower
HST	: Happy Seeder Technology
kg	: kilogram
kg ha^{-1}	:kilogram per hectare
kmph	:kilometer per hour
kN	:kilo Newton
KVK	: Krishi Vigyan Kendra
Lh^{-1}	:Liter per hour
LSR	:Loose Residue Removal
MIG	:Metal Inert Gas
m^2	: meter square
MJ Kg^{-1}	: mega joules per *kilos*gram
mg m^{-3}	: milligram per meter cube
MJ ha^{-1}	: Mega Joule per Hectare
mm	:millimeter

Mt ha^{-1}	:metric ton per hectare
Mt yr^{-1}	:Metric ton per year
ms^{-1}	: meter per second
NPK	: Nitrogen Phosphorus Potassium
NAAS	: National Academy of Agricultural Sciences
NO	: Nitric oxide
NO_2	: Nitrogen dioxide
NPV	: Net Present Value
NW	: North Western
PAR	: Photo synthetically active radiation
PM	: Particulate matter
Rpm	: Revolution per minute
SO_2	: Sulphur dioxide
SOC	: Soil Organic Carbon
SOM	: Soil Organic Matter
SPAD	: Soil Plant Analysis Development
SPM	: Suspended Particulate Matter
t ha^{-1}	: ton per hectare
TM	: Traditional Method
Viz.,	: Namely
USD	: United States Dollar
wb	: wet basis

ABSTRACT

Name of the Author	**:**	**MAHESHWARI**
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After the harvest of crop, the disposal of the rice stubble is a notable area of interest in allthe growing areas of rice. The main reason of crop residue burning is the creation of narrow gap between the harvesting of paddy and sowing of next crop. During the harvesting of paddy, the large units of harvesters leave 8-10 cm of paddy stalk and removal of this stuff is a labour intensive process. Till date, the farmers are following traditional method burning crop residues followed by clearing burnt matter by tree bushes, dibbling operation for punching holes and manual sowing of pulses and cereals especially paddy in south India, mainly the rice growing areas of Andhra Pradesh region which in turn has a significant negative impact on people's health, regional climate and crop output. The present study conducted at Research Farm of Dr. NTR College of Agricultural Engineering, Bapatla.

The Happy Seeder was tested to find the suitability of crops like black gram, green gram and Maize in different soils of the locality. Different performance parameters such as plant height, theoretical and effective field capacity, draft, field efficiency, ground wheel slippage, speed index, germination percentage were measured. However, the machine is unable to cover the furrow after dropping ofseeds which may affect the germination percentage of the seeds. Hence, developed a suitable furrow closer of furrow closers for happy seeder which is a small but needy thing for closing the furrows to increase seed- soil contact to get good germination. Developed furrow closers like L-Type at 30° and 120° inclination, roller type and double wheel type were evaluated and statistical analysis was applied to depict the furrow coverage of different furrow closers. L-Type blade with120° inclination and double wheel type gave the best results of furrow coverage. Happy Seeder was evaluated in three different types of soils namely sandy, clay loam and sandy taking three crops as reference black gram, green gram and maize in the Andhra Pradesh region for its feasibility.

It was found that high field efficiency of 63% was obtained in sandy soil at an operating speed of 3 km h^{-1} and low in black soil with 60%. The ground drive wheel slip of Happy Seeder was found more in sandy soil with 6.5% because of low resistance produced in the lugs of ground wheel causing more slip whereas in clay loam it was less i.e. 3.5% due to more traction provided to the lugs due its compact soil structure.

The maximum draft observed was 6.64kN at a depth of 7.2 cm in black soil whereas in case of sandy soil, it was 4.68kN at a depth of 6.7cm and in clay loam soil it was 5.42 kN at a depth of 6.3cm. The speed index was found more in sandy soil i.e. 0.25 indicating less clogging of soil in the straw management rotor followed by clay loam with speed index of 0.19 and black soil with a value of 0.17. The optimum speed of 3 km h^{-1} obtained the best results of field efficiency, fuel consumption and ground wheel slip in sandy, clay loam and black soil. Plant height of green gram, black gram and maize was almost more or less equal to that of traditional method compared to Happy Seeder technology.

The overall cost of operation for Zero-Till Happy Seeder was Rs.975.24 /- per hour whereas for paddy- maize traditional method it was Rs. 1143 /- per hour and for paddy- pulse traditional method it was Rs 859.6/- per hour. There was a saving of 100%, 6.6%, 75%, 50% and 33.3% in Happy Seeder method compared to traditional method of paddy-pulse cultivation in terms of tillage operations, fuel consumed, man and machine hours and number of irrigations, respectively and saving of 2.3%, 87.5%, 50%, and 33.3% in Happy Seeder method compared to traditional method of paddy- maize cultivation in terms of fuel consumed, man and machine hours and number of irrigations, respectively. It was concluded that to make the Happy Seeder feasible in the Andhra region, the use of rotary slasher after combine harvesting of paddy.

Keywords: ***Zero-Till Happy Seeder, Germination percentage, Ground wheel slippage, Speed Index. Rotary Slasher***

CHAPTER I

INTRODUCTION

Paddy is one of the most important Kharif crop which produces more than 20 million tonnes of biomass. An average of 1.5 crore tonnes of paddy straw is being generated in Andhra Pradesh every year, of which a large part is set on fire by farmers (P. Suryavanshi *et al.*,2022).Consequently, after the harvesting of paddy, farmers burn the paddy residue in the field itself which causes serious environmental problems and adversely affects soil health and crop output.

Rice (*Oryza sativa* L.) is India's most important crop, accounting for 23.3 percent of the country's gross planted area. In 2017-18, rice production and productivity in India were around 122.27 million metric tons and 2585 kg ha^{-1} respectively, covering an area of 35.23 lakh ha (*Anonymous*, 2021). In India, managing paddy straw left in combine harvested fields is a serious issue. Despite several uses such as cattle fodder bedding and shelter material for cattle, briquetting, and thermal power generation - a major part goes as waste or burnt in fields. This problem is mostly encountered in paddy-pulse, paddy-maize crop rotation as farmers assume this practice of burning to be quick and easy for disposing of paddy straw which enables them to plant the next crop well in time. Rice must be harvested early in the paddy-pulse cropping system to accommodate the pulse crop. This means that the farmers will have very little time to turn around and grow the pulse crop.

During the season, the farmer must clear the rice stubble and prepare the field for crop sowing. As a result, burning has become the easy and quick approach for dealing with paddy straw and stubble. Residue burning followed by direct drilling aids in the timely seeding of pulse after paddy in the paddy-pulse rotation in Andhra Pradesh. It lowers production costs, minimizes weed growth, conserves soil moisture, and boosts organic matter levels in the soil. However, due to loose straw and chaff distributed across the field surface after combine operation, direct drilling in combine harvested paddy fields is not practicable. This is because of straw accumulation in the drill's furrow openers, traction problems to the ground wheel due to the presence of loose straw, and non-uniform depth of seed placement due to frequent lifting of the implement under heavy trash conditions (Shukla *et al*., 2002).

The major use of crop residues in India and other countries are for fodder, cooking purposes, briquetting, composting, and use as an energy source. The burning of crop residue is a major problem all over the world, the best practices for effective management of crop residues are cutting, chopping, and incorporating in soil. The practice of straw burning is to be discouraged and stress on sustainable crop residue management practices need to be promoted by involving improved technologies, long-term research, and implementing policies for the same. Many researchers found that incorporation of crop residue into agriculture field would add soilnutrients and increases the crop productivity per unit area of land in long period.

Crop residue burning has become a major environmental issue causing health problem as well as contributing to global warming The main adverse effects of crop residue burning include the emission of greenhouse gases (GHG) that contributes to global warming and causes health hazards, loss of biodiversity of agricultural lands, and the deterioration of natural sources. Crop residue burning significantly increases the number of air pollutants such as CO, NH_3), etc. Therefore, paddy straw management is a burning problem and needs to be tackled. Zero-Till Happy seeder provides an economically viable alternative to residue burning. It allows farmers to sow the next crop immediately after the paddy is harvested without burning paddy residue for land preparation

The huge amount of paddy residues after the harvesting is to be cleared to sow the second crop. Keeping in mind the short period of time, farmers go for burning paddy straw residues after the combine operation because of interference of residues by tillage and sowing operations for the next crop. One tonne of paddy straw contains about 1.2kg Sulphur 5.5 kg Nitrogen, 2.3kg Phosphorous, and 25kg potassium. Therefore, these micronutrients incorporate the fertilizer requirement of the crop which is absorbed by the rice (Anonymous, 2014). There is a loss of large amount of micronutrients due to burning which leads to declination of soil health in additional to monetary loss. Many poisonous gases are produced during straw burning like carbon monoxide, carbon dioxide, methane, and nitric oxide. These gases not only harm human and animal health but also adulterate the surrounding environment. Various straw management techniques can be used to cope with this loss. India being an agriculture-dominant country produces more than 500 million tons of crop residues annually, (*Anonymous*.,2012. These residues are used as animal feed, for thatching of homes, and as a source of domestic and industrial fuel.

A large portion of unused crop residues is burnt in the fields primarily to clear the left-over straw and stubbles after the harvest. Non-availability of labor, high cost of residue removal from the field, and increasing use of combines in harvesting the crops are the main reasons behind the burning of crop residues in the fields. The declining water table in the Punjab State demands the development of new technologies and agronomic practices to enhance the water use efficiency for the cultivation of different crops. The major crop of this region is wheat occupying about 80% of the cultivable area and generally requires 4-5 irrigations when grown conventionally (Devinder *et al*., 2020).So, to tackle this problem of the declining trend of the water table, Happy Seeder Technology came into effect. Burning of paddy residues causes global warming as it produces harmful greenhouse gases leading to environmental pollution and resulting in loss of plant nutrients like N, P, K and S.

Paddy, then sowing of pulses is a major cropping pattern in the Krishna zone of Andhra Pradesh with major cropping intensity.In the Krishna zone, the traditional practice of sowing pulses after paddy harvesting is broadcasting of the seeds i.e. random scattering of seed on the surface of seed beds which increases the seed rate and the crop density per meter square and also leads to an increase in nutrient and vitamin supplements among the plants. It can be done manually or mechanically. With this method, the seed distribution is varying over the entire field and it is unable to maintain uniform plant-to-plant and row-to-row spacing. Apart from these, there are many drawbacks like higher seed rate, cannot get an approximation of the quantity of seed sown, higher weed growth, and unwanted crop growth. Even today, the farmers are burning the crop residues, especially paddy in south India due to problems faced by straw clogging in the machine which leads to air pollution and has a bad impact on people's health and regional climate, and crop output.

The Zero-Till Happy Seeder is the machine which is handed down for direct sowing in the standing stubbles of paddy residue. Punjab Agricultural University (PAU) proposed this machine which has well-favored for the plantation of wheat after paddy in North India but the suitability for the planting of pulses is not known and needs to develop a suitable furrow closer for Happy Seeder. The present availability of happy seeders has to be developed with suitable furrow closers for closing of furrow with seed placement to deposit the residue content of paddy and left over from the farm over the sown area. This method of sowing pulses into the harvested paddy fields helps to conserve soil moisture, labor, time, and cost of operation and reduces hazardous impacts on the environment. By keeping the above problems in mind, following objectives were investigated.

OBJECTIVES

1. To test the feasibility of tractor-operated Zero-Till Happy Seeder under different soil conditions.
2. To develop a suitable furrow closer for Zero-Till Happy seeder.
3. To estimate the cost economics and savings of time and energy in comparison with the traditional methods.

CHAPTER II

REVIEW OF LITERATURE

A brief resume of work done in India and abroad was reviewed and documented which is an essential part of scientific investigation. Therefore, an attempt has been made to review the research studies related to the feasibility of Zero-Till Happy Seeder under different soil conditions of Andhra Pradesh. The key findings of the present research work have been presented in the following sections.

2.1 BRIEF RESUME OF WORK DONE

2.1.1 Performance Evaluation of Happy Seeder in Comparison with the Traditional Method
2.1.2 Effects of Paddy Residue Burning
2.1.3 Socio-Economic Impact of Using Happy Seeder on Farmers
2.1.4 Study on Different Straw Cutting Machinery for Paddy Straw Management
2.1.5 Different types of Furrow Closers
2.1.6 Options for Paddy Straw Management
2.1.7 Performance Evaluation of Residue Management Machine

2.1.1 Performance Evaluation of Happy Seeder in Comparison with Traditional Methods

Jitendra *et al.* (2021) conducted research work on the comparative performance of the conservation machinery system for the Rice-Chickpea cropping system in vertisols of Chhattisgarh. Trials were conducted with mainly four machines named ridge and furrow planter sowing, conventional seed cum fertilizer drill, zero till drill sowing, and happy seeder with T1, T2, T3, and T4 as treatments. In T1 treatment, fuel consumption and yield attributes like test weight, and seed yield were higher whereas in T3 and T4 higher conservation of moisture was observed due to the incorporation of straw. The total energy input required in T1, T2, T, and T4 treatments are 9221.5, 7842, 5448.5, and 5520 MJ ha^{-1} respectively. Minimum energy input requirement was observed in T3 treatment due to no-tillage followed by T4. Cost of cultivation was found less i.e. 2331.79 Rs ha^{-1} in the happy seeder sown field compared to the other treatments.

Memoona *et al.* (2020) studied the environment resilient rice stubble management for Wheat sowing in zero tillage happy seeder. Field experiments were conducted at agronomic research station, Farooqabad to evaluate the various residue management techniques namely happy seeder, conventional method with and without burning, rotovator 2 passes using a randomized complete block design. It was found that maximum plant height (94.74 and 94.25 cm), number of productive tillers per m^2 (324 and 322), 100-grain weight (36.35 and 36.20), grain yield (3780 and 3613 kg ha^{-1}), and benefit-cost ratio (2.54 and 2.43) were recorded from happy seeder treatment respectively. It was concluded that happy seeder technology was more appropriate and environmental friendly.

Naveen *et al.* (2020) studied the performance evaluation of happy seeders in comparison with Zero-till drill for sowing methods. It was done based on field capacity, fuel consumption, and cost of operation. The field efficiency of happy seeder was 74.72% and 63.33% for zero till drill at an operating speed of 3.5km h^{-1}. The cost of operation for a happy seeder was 2382.70 Rs ha^{-1} and with that of zero till drill including straw collection by manual labor was 3200 Rs ha^{-1}. Happy seeder showed its effectiveness in terms of all parameters of inspection for sowing wheat in a combine harvested paddy field.

Yogesh *et al.* (2019) studied the performance evaluation of happy seeders for sowing chickpea in the rice-chickpea cropping system of Chhattisgarh. The project was organized for the evaluation of different chickpea sowing technologies under paddy residue conditions carried out in a harvested paddy field. Field of paddy variety (R-1) was harvested with a combine. The stubble load was 7.16 t ha^{-1} with a moisture content of 26.9%. Chickpea variety (JG-130) was sown directly with a happy seeder without any land preparation and sowing with conventional seed cum fertilizer drill required tillage practice (MB Plough + Cultivator + Rotovator) by several passes. In happy seeder, all the paddy straw was leftover in the field itself and spread uniformly without the requirement of any tillage practice. While in conventional methods land preparation is required before sowing of seed. The overall yield of chickpea grain was obtained in happy seeder (1137.8 kg ha^{-1}) than conventional seed cum fertilizer drill with 1067.29 kg ha^{-1}.

Singh *et al.* (2019) studied the economic assessment of the happy seeder for rice-wheat systems in Punjab, India. The primary aim of the project was to conduct a preliminary assessment of the benefit and cost ratio by using the happy seeder in comparison with the conventional tillage before sowing. The outcome suggested that zero till drill was more profitable than direct drilling after burning and also it is profitable for farmers. The present value of the benefits was thoroughly responsive to yield; a 5% increase in yield with the zero till drill doubles the rise in the Net Present Value of the happy seeder over conventional tillage. This value is also quite sensitive to changes in herbicide use, and less sensitive to changes in irrigation water saving and discount rate. To widespread the adoption of technology, a range of potential, mechanical, technical, social, institutional and policy constraints need to be considered and addressed in conjunction with a detailed economic assessment of the happy seeder technology.

Ram pal *et al.* (2018) studied zero till drills to access the suitability for crop residue management. The rice-wheat system was intensively cultivated when the straw content of paddy was 50% burnt before sowing. Changes were noticed in plant population, grain yield, and bundle weight while doing trials in fields. The research study came to an end to conclude that the use of happy seeders not only increases production income but it also conserves most natural resources like water, soil, and labor. Paddy stubbles were used as a mulch cover. The results disclosed that the net benefits were almost doubled for a 5% increase in the yield with this method over the conventional tillage.

Iqbal *et al.* (2017) evaluated the happy seeder in comparison with the conventional wheat sowing method. Wheat sown by the happy seeder had a higher germination count than the conventional method. The number of effective tillers, the weight of 1000 grains, and grain yield were all significantly higher in happy seeder sown wheat compared with the conventional method. The net income was 112938 Rs ha^{-1} compared to the conventional method which had a net income of 102602 Rs ha^{-1}. They concluded that the happy seeder was a good straw management option for paddy farmers as it facilitates the timely drilling of wheat in a single pass. On the other hand, crop sown by happy seeder is also less affected by rain over-irrigation. The utilization of happy seeder does not only guarantee better yield but also saves energy and diesel, hence it is the most cost-effective practice.

Prashant *et al.* (2017) studied the performance evaluation of happy seeders for sowing wheat in the field harvested by combines. The performance execution of zero till happy seeder with the conventional method was evaluated and showed its effectiveness over the sowing technique. The assessment of performance was done based on field capacity, field efficiency, actual field capacity, fuel consumption, and cost of operation of happy seeder with the conventional method of sowing wheat in a combined harvested paddy field, to prove the effectiveness. The operating speed was varying from 2.5 to 3.5 km h^{-1} to evaluate the variables. The field efficiency of happy seeders was 43.4% and 65.04% for seed drill at an operating speed of 3.5 km h^{-1}. The cost of operation per hectare by happy seeder was Rs. 2098.65 and the cost of operation per hectare by seed drill + tillage operations was Rs. 3106.38. Therefore the cost of operation with a happy seeder is economical as compared to a seed drill by 1008.38 Rs ha^{-1}.

Gurmeet (2016) studied the comparison of evaluation of happy seeder over normal sowing in wheat in the adopted village in Bathinda district of Punjab. This work was done at KVK, Punjab as crop rotation of paddy followed by wheat is a major cropping pattern. This research suggested that rice residues which are of primary importance for farmers and fodder purposes were completely burnt with the conventional burning method. So, to combat this need as well as to reduce pollution hazards, happy seeder technology was used for sowing wheat where rice residues acted as a mulch cover over the crop conserving moisture and reducing production costs, and labor. This technology saved 2311.00 Rs ha^{-1} over the normal practice of sowing and straw burning method along with an increase in grain yield and a decrease in the use of fertilizers. It was concluded that this technology saved 3400 Rs ha^{-1} if the straw was burnt partly and 6200 Rs ha^{-1} if remained in the field unburnt.

Avatar *et al.* (2013) studied the different methods of planting for in-situ straw management of paddy i.e. happy seeder and rotovator technology in comparison with the farmer's practice in four districts of Punjab mainly Jalandhar, Kapurthala, Patiala, and Fatehgarh Sahib in two different types of soil namely; loamy sand and sandy loam soils. Loamy sand contained a high amount of NPK compared to sandy loam soil. Data was recorded on grain and straw yield during the Kharif season. An average of 33.6 kg ha^{-1} N, 7.48 kg ha^{-1} K and 65.85 kg ha^{-1} P. It was found that the happy seeder and rotovator produced the same or slightly higher grain yield as compared to farmer's practice and found to be the best method for in-situ straw management which reduces the cost of production and improves the soil productivity.

Ridhima *et al.* (2012) studied the environmental problems facing South Asia known as Atmospheric brown clouds as a consequence of the burning of straw residues. This type of air pollution harms crop yield, climate, and individual health. This study was undertaken by SANDEE (The South Asian Network for Development and Environmental Economic) which collaborates with analysts from different countries in South-East Asia to express their problems about the environment and development related. This committee covers Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka. Research suggests that farmers in India burnt 116 million Mt in 2001. Open burning of crop residue accounts for 25% of carbon, and CO emissions, 9-13% of fine particulate matter (PM2.5), and 1% of SO_2 emissions.

2.1.2 Effects of Paddy Residue Burning

The problem of paddy residue burning has been rapidly increasing and spreading across the Indian subcontinent resulting in deterioration of air quality in a vast geographical area. Crop residue burning is one of the major causes of atmospheric pollution in north western states of India and this has serious economic implications as well as adverse impacts on soil, environment, animal, and human health due to the emission of huge quantities of harmful air pollutants (NAAS 2017). Therefore, the issue of paddy residue burning is a genuine problem that requires urgent attention and collective efforts.

Kumar *et al*.(2019) conducted a study to investigate the effect of paddy straw burning on soil microbial dynamics. Soil samples were collected from a depth of 10 cm at different intervals over a 60-days period. The treatments were: (i) burnt paddy crop residues (T1); (ii) manually removed paddy residues (T2); (iii) fully retained paddy residues (T3). In treatment where crop residues were burnt, a significant population reduction in the main groups of microorganisms-bacteria, fungi, actinomycetes, phosphate solubilizing microorganism (PSM), potassium solubilizing microorganism (KSM), and cellulose degraders. Likewise, there was a transient decline in microbial enzymes as well as other soil health properties after burning the paddy crop residues. Moreover, the population of microorganisms and enzyme activities responsible for the recycling of biomass failed to recover after 60 days as there were no substrates available. It was concluded that in the long run, this may lead to deleterious effects on soil health.

Kumar *et al*.(2019) conducted a study to identify and estimate the environmental and social cost of burning paddy crop residues in North-west India. Different components of the total cost included a decline in yield of the subsequent crop, loss of nutrients due to paddy crop residue burning, deterioration of soil health, and cost of providing the initial irrigation after burning the residues and before sowing the next crop. Using extant coefficients, it was estimated that cost of paddy residue burning is 8953 Rs/ha, and the social cost of burning is Rs.3199 crores per annum in the region.

Balakrishnan *et al*.(2019) reported that in 2017, about 76.8 % of the people in India were exposed to annual population-weighted mean PM2.5 greater than the limit recommended by the National Ambient Air Quality Standards (NAAQ: 40 mg m^{-3}). It was also mentioned that air pollution is the second highest health risk factor in India.

Jain *et al.* (2014) also reported the emission of pollutant gases such as oxides of sulphur and nitrogen, ammonia, and other volatile organic compounds which are responsible for forming particulates in the air. They concluded that approximately more than 8.5 Mt of CO, 141 Mt of CO_2, and 1.21 Mt of particulate matter were released into the atmosphere in India during the 2008-09 season due to crop residue burning.

Agarwal *et al*.(2012) carried out a 3-year study in Patiala (India) to determine the 5 effects of exposure to smoke produced from paddy residue burning on levels of pulmonary functions and Oxygen Saturation (SpO_2) level in human beings. They performed pulmonary function tests on a sample size of 50 healthy subjects from five different sites of Patiala. The parameters investigated during the paddy crop residue burning period included force vital capacity (FVC), force expiratory volume in one second (FEV1), peak expiratory flow (PEF), and force expiratory flow between 25-75 % of FVC (FEF 25–75%), as well as SpO2 levels. Concentration of particulate matter (PM), SO2, NO2, and SPM levels were measured. The level of pollution in the ambient air significantly increased as a consequence of burning the paddy residues, and the pulmonary function tests experienced a decline in their corresponding values. It was concluded that the decline in the quality of air had sub-acute consequences on pulmonary functions of healthy subjects

Gadde *et al.*(2009) estimated the quantity of rice straw subject to open field burning in India, Thailand, and the Philippines through an adequate calculation methodology and the quantitative contribution of these burning practices on air pollution using appropriate emission factors. They reported that crop residue burning emits not only CO, non-methane hydrocarbons (NMHC), SO_2, particulate matter (PM), and greenhouse gases (CO_2, NO, and CH4) but also contributes to global warming and climate change. However, CO_2 emitted from biomass burning is considered to have a neutral effect due to its photosynthetic uptake during plant growth.

2.1.3 Socio-Economic Impact of Usage of Happy Seeder on Farmers

Pooja *et al.*(2020) studied the impact of happy seeders on the socio-economic status of farmers in Haryana. The study was conducted in two agro-climate zones of Haryana namely the dry zone and wet zone. Two districts i.e. Kaithal and Fatehabad were randomly selected from both zones. From each of the two selected districts, one block i.e. Pundri from Kaithal and Ratia from Fatehabad were randomly selected. 30 adapters and 30 non-adopters were selected. The findings of the study revealed that the knowledge level of adopters was more positive as compared to non –adopters and major reasons for adoption were that happy seeders is an environment-friendly technology which reduces fuel and labor cost, improves soil health & increase yield than conventional method whereas shortage of information, more hiring charges, not beneficial and affordable were the reasons for non-adoption. To increase the rate of adoption of Happy Seeder technology, extension activities should be increased among farmers.

Sukhdeep (2011) conducted a census study on Discriminatory analysis of adopters and non–adopters of Happy Seeder in wheat crops. Farmers who adopted happy seeders were selected out of which 40 adopters were randomly selected. Along with this, the same numbers of non–adopters were selected. In this study, information regarding different stages adopted by adopters and non–adopters, different sources for the adoption were taken up for the research. The majority of adopters were in the middle age group with high educational background, risk bearing, innovativeness patience, took less time for adoption, and were having large landholdings whereas non–adopters were youngsters with low level of knowledge and small land holdings compared to those of adopters. Reasons for adoption were the low cost of sowing and the required less irrigation and that for non-adoption were low subsidy of the machine, difficulty in straw management, and peer pressure.

2.1.4. Different Types of Furrow Closers and Seed Covering Device

Kojo *et al*.(2019) reviewed the performance comparison of residue management units of no-tillage sowing systems. This article examines the effectiveness of residue cover (>30%) on sown rows, preventing the interference of residues with the opening and closing of furrows (blockage), depth control, seed spacing, and its influence on fuel consumption and draft requirements. Smooth disc coulters, finger row cleaners, and their combinations retained maximum coverage over no-tillage systems whereas power-assisted units can operate with straw load up to 9000kg ha^{-1} but it requires high fuel consumption.

Nandede *et al*.(2014) experimented with soil bins on different types of furrow closers and openers to test the draft requirement, depth of operation, and soil coverage of semi-automatic vegetable transplanters. Two types of furrow closers were inclined mild steel plate (PL) and double disc closer (DC) and furrow openers were shovel (SL), shoe (SE), and runner type (RR). Criteria for Selection of the best combination of furrow opener and furrow closer were less draft and minimum soil coverage of 100%. It was observed that both draft and soil coverage for all furrow openers tested with both draft and soil coverage. Using the Duncan Multiple Range Test, the SL opener with DC was the best suitable combination as it was giving soil coverage with slightly more draft than the SL opener with PC. Maximum coverage (104.4%) was found more for the 20°C closer angle was selected as it gave required minimum soil coverage with lesser draft compared to the 20°C closer angle.

2.1.5 Options for Paddy Straw Management

The most common practices for utilizing paddy residues include bedding for animals, composting, mushroom cultivation, biofuel, fuel for furnaces, electricity generation, roof thatching, manufacturing of papers, mushroom cultivation, in-situ mulching, and incorporation (Lohan *et al*. 2018).

Chaudhary *et al*. (2021) studied on the effect of wheat establishment methods under different rice residue levels on growth and productivity. Experiments were conducted at G.B. Pant University of Agriculture and Technology, Pantnagar which was laid in a split-plot design having three wheat establishment methods viz., conventionally, happy seeder, and super seeder in main plots, and three rice residue levels viz., complete residue removal, only loose straw removal and no residue removal in sub plots. The number of shoots and spikes per m^2, grain yield and straw yield, plant height (30 DAS), SPAD and green seeker values (60 DAS) were found higher with happy seeder sown wheat. Among rice residue levels, these parameters were recorded higher with loose straw removal recorded than complete removal and no residue removals. During both years, the total weed accumulation was lowest with happy seeder (1.58 and 1.40 g m^{-2}) and recorded higher moisture content (0-15 cm) than residue removal treatment. The use of happy seeder sown wheat under CRR treatment recorded the lowest fuel consumption and CO_2 emission.

Alwin *et al*. (2020) reviewed the changing agricultural stubble burning practices in the Indo-Gangetic plains. Different tillage practices are eco-friendly and profitable to farmers to adopt no-burn technologies, especially the 'Happy Seeder' which sows wheat directly into the rice residues. Apart from these, factors influencing the adoption of the HS, impact wheat yields and production costs. It was revealed that savings in wheat production accounted for 136 USD ha^{-1}. Finally, it was summarized that HS has both private and public benefits like savings of irrigation and facilitates timely wheat sowing, reducing air pollution

Chethan *et al*.(2020) worked on crop residue management to reduce greenhouse gas emissions and weed infestation in Central India through mechanized farm operations. A field experiment was conducted using three treatments namely current farmer's practice (FP), and conservation agriculture with and without weed management (CAW and CA). Crop residue of about 51 tonnes generated from 2 ha of Rice-wheat-green gram was burnt in FP, but it was utilized as mulch in CA and CAW. Thus, 34400 kg CO2 emissions were avoided and an energy potential of 100.1*104 MJ was created. It was found that CAW produced a higher yield i.e. in rice (4.6 and 4.1 t ha^{-1}), wheat (4.9 and 4.1 t ha^{-1}), and green gram (1.3 and 1.3 t ha^{-1}).

Trivedi *et al.* (2017) revealed that instead of burning paddy crop residues, they can be effectively exploited for the production of biofuels such as bio-methane and bio-ethanol which can produce energy equal to 8.0 GJ ton^{-1} and 5.6 GJ ton^{-1}, respectively. Moreover, paddy straw can be processed into pellets that be utilized. In this study, various straw management techniques like straw incorporation, retention, and removal and their influence on nutrient availability, and crop water requirement were analyzed. It was found that retention was more advantageous compared to the other two in terms of energy, time, and cost-effectiveness along with moisture conservation, weed infestation, temperature regulation, and improved soil health. Combines fitted with straw management systems and turbo happy seeder and rotary disc drill. It was concluded that for the smooth running of machinery, the height of the anchored straw should be of short length so that less straw load will enhance better residue management.

Xianyang *et al*.(2005) studied the utilization of straw in biomass energy in China. This paper reviews the present technologies of straw conversion and utilization including improved stove, biogas, straw gasification, and briquette which are already commercialized and popularized. The study revealed that the Utilization of straw as energy with high efficiency and rationality not only meets the demands for energy as the economy grows but also provides a basis for environmental protection and sustainability.

Krishna *et al*.(2004) investigated the study of different rice residue management techniques and their effects on soil properties and crop productivity. This study revealed that the rice-wheat system yields 7 t ha^{-1} rice and 4t ha^{-1} wheat which removes about 300 N, 30 P, and 300 K kg ha^{-1}. It was found that straw incorporation obtained higher yield compared to burning. Surface retention increased the soil N% uptake by 29% and yield by 37% compared to burning. As a whole, these practices affected the soil physical properties like moisture, temperature, bulk density, and hydraulic conductivity. Rice straw incorporation coupled with an increase in organic manure, and grain yield at its head side resulted in more pest infestation than residue removal and burning at its toss side.

2.1.6. Performance Evaluation of Residue Management Machine

Singh *et al*. (2011) evaluated the performance of tractor-mounted straw chopper cum spreader for paddy straw management. The main parameters of this study were two levels of moisture content of paddy straw (30 and 40%, wb), three levels of chopping speed (1300, 1450, and 1600 rpm), and three levels of forward speed (2.0, 2.5 and 3.0 km h^{-1}). An optimal combination of variables was selected based on the size of the straw cut, uniformity of straw spread, and fuel consumption. It was observed that the effect of moisture content on the size of chopping was found to be non-significant and the percent size of cut (up to 4 cm) of paddy straw increased with an increase in chopper speed and decreased with an increase in forward speed. No independent variables showed significant effect on the uniformity of straw thrown. The effect of forward speed was more pronounced on fuel consumption than the effect of chopping speed. It was concluded that a suitable combination was obtained at a chopping speed of 1450 rpm and a forward speed of 2.0 km h^{-1}.

Elfatih *et al*. (2010) evaluated the performance of the modified chopper for rice straw composting. The results showed that increasing the cutting drum linear speed from 56.6 ms^{-1} to 70.7 ms^{-1}, increased the cutting efficiency, the chopper productivity, and the power requirement by the percentage of 3.7%, 2.8% and 0.9%, 57.5%, 55.9% and 41.7%, 36.8%, 28.6%, and 35.9%, respectively, meanwhile, decreased the energy consumption by a percentage of 32.7%, 38.4 and 9% for 35 mm, 25 mm, and 9 mm concave hole diameter, respectively. They explored that the shortest composting period of 95 days resulted from using a 25 mm concave holes diameter at 66 m/s cutting drum speed, meanwhile, the longest period of 140 days resulted from using the 9 mm concave holes diameter at 70.7 ms^{-1} cutting drum speed. Also, it was observed that using the 35 mm concave holes diameter at 56.6 m s^{-1} cutting drum speed.

El-Hanfy, E. H and S. A. Shalby (2009) evaluated the performance of modified Japanese combine chopping units during the harvesting operation. The performance evaluation of the chopping unit was conducted under four forward speeds (0.35, 0.55, 0.75,and 1 ms^{-1}), three cutting speeds (450, 550, 650 rpm), and three distance overlapping between fixed and rotary knives (6, 8,10cm). The results showed that the suitable forward and cutting speed and overlapping between fixed and rotary knives are (0.75 ms^{-1}, 550 rpm, and 10 cm) respectively. Also, data revealed that the excessive forward and cutting speed increased combine trouble.

SS Thakur and IK Garg (2007) conducted a study on paddy straw management by chopping for sowing wheat in a combined harvested field. Fuel consumption and size of cut of paddy residue as performance parameters were taken. Parameters focused were chopper speed, forward speed, and moisture content against the size of cut and fuel consumption. The results showed that the percent size of cut (less than 10 cm length) of paddy residue increased with the increase in the chopper speed and moisture content but decreased with an increase in the forward speed. It was observed that to get better performance of stubble harvester-cum-chopper, it should be operated at 70% (w.b) moisture content of the stubbles, with a forward speed of 2.0 km h^{-1} and at a chopper speed of 1500 rpm. It was suggested that chopping of paddy stubble was recommended immediately after combine harvesting.

Garg I K (2004) developed a rice straw chopper-cum spreader for the paddy crop. This machine harvests the stubbles in a single operation after combine harvester, chops them into pieces, and shreds them on the ground. The chopped and spread stubbles were then easily buried in the soil with rotovator or disc harrow. Subsequently, wheat sowing was done by the use of the strip-till drill. This machine consisted of flail blades around rotary shaft to harvest the straw and knives as chopping unit, operated by a 45 Hp tractor with 228 cm working width. It was examined that the machine gave the best performance results initially. The machine chopped the paddy stubbles at a chopper speed of about 1500 rpm and flail speed and the average length of straw cut was 7–10 cm.

2.1.5. Energy and Cost Economics of Traditional Versus Happy Seeder Method

Parveen *et al.(*2021) studied the comparison of the energy consumption in traditional and advanced paddy residue management technologies for wheat sowing using different techniques i.e. retention, incorporation, and removal of straw. Ten different types of treatments used were Combine harvester with straw management system (SMS) +Zero till drill, Spatial till drill, and happy seeder in straw retention plot. T2 was done using the straw incorporation technique with a combine harvester with SMS+ Reversible MB Plough+ Seed drill, Rotovator (2 passes)+ Seed drill, Disc harrow (3pass)+ Planker+ Seed drill, Rotovator+ Manual broadcasting +Rotovator. The T3 was done using straw removal by traditional combine + Stubble shaver +Straw baler+ Disc harrow (2 passes)+ Planker+ Seed drill, Hay Rake+ Straw baler+ Disc harrow (2 passes)+ Planker+ Seed drill. Traditional straw removal + Disc harrow (2 pass)+ Planker+ Seed drill. Specific energy requirement was more in removal and incorporation of straw residue practices compared to the retention method.

Singh *et al.* (2021) studied the energy optimization in wheat establishment following rice residue management with Happy Seeder Technology for reduced carbon footprints in north-western India. In this research energy efficiency and carbon footprints of happy seeder sown wheat were evaluated. The energy input-output and carbon footprints were audited to optimize energy use and carbon equivalent emissions followed by rice residue management with happy seeder using data collected from 53 farmers during a face-to-face interview. Energy productivity of 0.24 MJ kg^{-1} was obtained with the energy input of 23.5 GJ ha^{-1} and output of 208.4 MJ ha^{-1}. Chemical fertilizers were the major contributor to energy.

Sidhu *et al.(*2015) studied the development and evaluation of the turbo happy seeder for sowing wheat into heavy rice residues in North-western India. In this study improved version of the happy seeder was developed i.e. version 2 of the 9-row turbo Happy Seeder has a weight of 506 kg operated by 33.6 kW at a field capacity of 0.3 ha h^{-1}. It was found that yield of this improved version was similar to or higher than with straw burning and conventional tillage prior to sowing along with reduced fuel consumption, cost of production, and savings of irrigations. Constraints to adoption include low duration of operation, low capacity compared to conventional seed drills, lack of straw spreaders, and inability to operate in wet straw despite a 50% subsidy.

Singh *et al*.(2013) studied the feasibility of happy seeder for clearing paddy residues in central Punjab conditions. Field trials were done at nine different locations to evaluate the performance under heavy soils of district Fatehgarh Sahib. It was observed that weeds were found less in happy seeder sown compared to the traditional method. Wheat yield in these years varied from 35-56.25 q ha^{-1} and 31.75-50.75 q ha^{-1} for happy seeder and conventional methods respectively with an average increase in yield of 8.84% in happy seeder plots.

2.1.6. Savings of Energy in Comparison with Traditional Methods

Jianwei *et al.(*2020) studied the long-term straw incorporation on rice yield stability under high fertilization level conditions in the rice-wheat system. The effect of straw returning on rice yield and yield stability were observed. The results showed that straw incorporation did not significantly affect the average rice yield over nine years. Straw incorporation reduced the coefficient of variation of rice yield by 25.8% and increased the sustainable yield index by 8.2%. Rice yield was positively correlated with mean photo synthetically active radiation (PAR). Straw incorporation increased the rice yield by 5.4% in the low PAR years rather than in high PAR years. Long-term incorporation lowered bulk density but improved soil organic matter, and NPK content better than straw removal. The key findings suggested that straw incorporation improved rice yield more than straw removal when exposed to low PAR.

Amanpreet *et al.(*2016) studied the economic assessment of conservation agricultural practices with special emphasis on Happy Seeder technology (HST) and Traditional Method (TM) for the rice-wheat system in Punjab. The study included a survey on four districts of Punjab in terms of input use, cost-effectiveness, and addressing sustainability issues. Growth analysis under resource conservation techniques (RCTs) showed 12.49, 6.92, and 9.96 % annum significant growth rates respectively. Input use pattern revealed that saving of 6.57 and 18.09% man and machine labor hours ha^{-1} with HST. Results showed that surface retention of rice straw resulted in 3.13% savings of fertilizer doses with HST. The cost of operation was low in HST compared to TM. The returns per rupee spend in TM were 1.81 against 1.86 in HST. It was found that yield was more with HST (45.09 q ha^{-1}) over TM (44.58 q ha^{-1}) mainly due to better germination and better crop stand. The study suggested that for faster adoption of HST subsidy should be made hassle-free keeping in view the high cost of the machine.

Devinder *et al.(*2019) studied the Evaluation of Happy Seeder as a Resource Conservation Technique in Ludhiana District of Punjab in India. The present study was conducted in four villages of Ludhiana viz., Begowal, Lall Kalan, Mallipur, and Arachian to assess the economic viability, conservation of soil and water resources, impact, and prospects of Happy Seeder Technology. The majority of farmers (65%) reported that there was a saving of one irrigation (70mm) i.e. average water requirement was 215mm compared to 285mm in conventional sowing. It was also found that sowing with this method resulted in the rejuvenation of soil microflora and fauna, reduction in weeds i.e. Phalaris minor to an extent of 62%, and better crop health compared to the conventional method.

2.2 Salient Findings from the Review of Literature

a. Burning of crop residues in paddy harvested fields contributes to atmospheric pollution, and has adverse effects on soil health and crop output.
b. In-situ paddy residue management conserves moisture in the field resulting in better soil physical and chemical properties.

c. The grain yield was higher in the happy seeder method compared to the traditional method and burning practice using seed drills.
d. Utilization of happy seeder is the most effective practice which not only guarantees better yield, but also saves labor, time, and energy compared to the traditional methods.

Therefore, to study the feasibility of usage of happy seeder for sowing black gram, green gram and maize in the Krishna zone of Andhra Pradesh in three different soils was under taken.

CHAPTER III

MATERIALS AND METHODS

This chapter presents the detailed procedure followed and materials used to achieve the objectives of the study entitled "Study the feasibility of Zero-Till Happy Seeder under different soil conditions of Andhra Pradesh region. It consists of different traditional methods followed by farmers for Paddy-Pulse cultivation. Development of different types of furrow closers for Happy Seeder, feasibility testing of Happy Seeder under three different soil conditions and three crops namely, Black gram, Green gram and Maize in different types of soil.

3.1 EXPERIMENTAL SITE

The experiment was conducted at the Research Farm of Agricultural College, Bapatla. The geographical location of the experimental site is 15°54'16''N and 80°28'3''E with an elevation of 6 meters above the sea level from the coast of Bay of Bengal. The average daytime temperature was 31°c and the average nightly temperature was 25°c with a humidity of 53-55% and wind speedof 6-7 m s^{-1} towards south.

3.2 PROCUREMENT OF RAW MATERIAL

The raw material used for the fabrication of furrow closers i.e. mild steel, angle iron was procured from Dr. NTR College of Agricultural Engineering, Bapatla and the seeds (Black gram, Green gram and Maize), Bapatla from the department of Agronomy, Agricultural College, Bapatla.

3.3 DIFFERENT METHODS OF RICE RESIDUE MANAGEMENT TECHNIQUES FOLLOWED IN COASTAL ANDHRA

3.3.1 Traditional Method of Paddy-Pulse and Paddy-Cereal cultivation

In this method of paddy-pulse and paddy-cereal cultivation, harvesting of paddy is done by combine harvester followed by rotary slasher operation which manages leftoveranchored straw. After this step, burning of residues left in the field takes place. After burning, clearing of the residues is carried by attaching the tree branch and dragging to the tractor. This operation is done to clear the burnt residues and smoke coming out of it followed by dibbler operation for making holes for placing seeds. This method is mostly used for sowing cereal like maize as well as pulses like Black gram and Green gram. Sowing is done manuallywithout any seed bed preparation. The steps followed in traditional method for paddy-cereal cultivation is shown in Fig 3.1

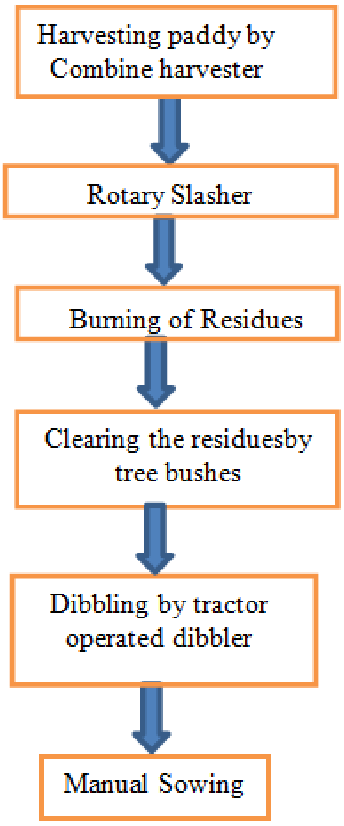


Fig 3.1 Traditional method of paddy-cereal cultivation

Step I: Combine harvested paddy field

After harvesting paddy by combine harvester, the leftover anchored residues are cut to a length of 7-10 cm using rotary slasher. The combine harvested paddy field is given in Plate 3.1.

Plate 3.1 Manually collected and heaped paddy straw in combine harvested field

Step II: Usage of rotary slasher

The anchored straw residues are to be managed by rotary slasher in one pass. Rotary slasher is a tractor PTO mounted implement which is most suitable for slashing paddy straw residues anchored to the soil which runs at 1012 rpm. It takes 15 minutes to cover one acre. It also very well serves the purpose of maintaining grasslands, road verges and lawn. Rotary slasher is the most versatile machine of grass cutting i.e. slashing. The Specifications of rotary slasher used in the study is given in Appendix –B. The rotary slasher used for shredding the paddy straw residues after the combine operation is given in Plate 3.2

Plate 3.2 Use of rotary slasher after combine harvesting

Step III: Burning of crop residues

Burning of residues in paddy field is generally used practice by most of the farmers in Northern India and it has acquired in the Southern region of paddy belts of Coastal Andhra Pradesh. This step is less time consuming but has a negative impact on environment, people's health and crop output. Burning of paddy residues is given in Plate 3.3.

Plate 3.3 Burning of crop residues in paddy field

Step IV: Clearance of burnt residues using tree branches

After burning of residues, the ash content and un-burnt residues are to be cleared for permitting the sowing of next crop. This practice is mostly seen in the coastal region of Andhra Pradesh. It is done by long tree branches tied with a rope to the tractor which is run all around the field to evenly spread the left over small residues , ash etc. Clearing of burnt residues using tree branches is given in Plate 3.4.

Plate 3.4 Clearing of burnt residues using tree branches

Step V: Dibbler operation for making holes

After clearing of burnt residues, a 5- row dibbler is attached to the drawbar of tractor for making punches in the soil for seed placement at standard row spacing of 6 inches. Most commonly used dibbler for dibbling or punching operation is shown in Plate 3.5

Plate 3.5 Dibbler operation

Step VI: Manual sowing

After the dibbling operation the seed are placed in dibbles manually done by farm women mainly crops like maize, green gram and black gram in Plate 3.6. This step is more time consuming and laborious compared to direct sowing with seed drill.

Plate 3.6 Manually placing seed in dibbles

3.3.2. Traditional Method of Paddy-Pulse Cultivation

This is another method of paddy-pulse cultivation followed in Andhra Pradesh which includes burning of paddy residues followed by tillage operation by rotovator and broadcasting of seeds. In this method only pluses like black gram and green gram are sown. The steps followed in traditional method of paddy-pulse cultivation are given in Fig 3.2.

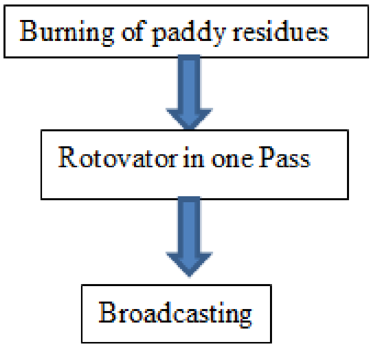


Fig 3.2 Traditional method for paddy-pulse cultivation

Step I: Burning of paddy residues

Burning of residues in paddy field is generally used practice by most of the farmers in Northern India. But in the recent post, this practice has gained popularity in the Southern region of paddy belts of Coastal Andhra Pradesh. This step is less time consuming but has a negative impact on environment, people's health and crop output. Burning of paddy residues is shown in Plate 3.7.

Plate 3.7 Burning of paddy residues

Step II: Rotovator in one Pass

Burning of residues followed by rotovator operations in one pass is employed tillage operations. Rotovator operation after burning is shown in Plate 3.8

Plate 3.8 Rotovator in one pass

Step III: Broadcasting

After rotovator operation for tillage, broadcasting of seeds is done by scattering the seeds over the field. Broadcasted pulses like Black gram and Green gram is shown in Plate 3.9.

Plate 3.9 Broadcasted pulse crop

3.4 HAPPY SEEDER TECHNOLOGY

In this method, harvesting of paddy using combine harvester is followed by sowing with thehelp of Happy Seeder. Burning of residues is eliminated in this method. The anchored straw left over after the combine operation are managed with the help of straw management rotor which consists of flail blades which works like a rotovator to cut and spread the straw residues as a surface cover for moisture conservation.

3.4.1 Steps Followed in Happy Seeder Method for Paddy-Pulse/Cereal Cultivation

With Happy seeder, direct sowing of pulses like black gram, green gram and cereals like maize is done in the combine harvested paddy field. The steps followed in Happy Seeder method for Paddy-Pulse/Cereal Cultivation is given in Fig 3.3.

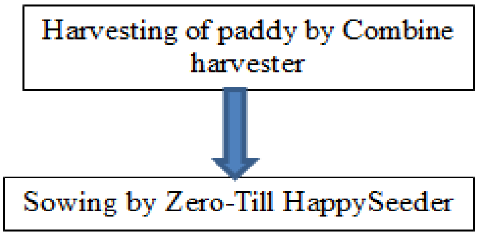


Fig 3.3 Happy Seeder Technology

Step I: Combine harvested paddy field

Paddy field after the harvesting with combine is shown in Plate 3.10

Plate 3.10 Combine harvested paddy field

Step II: Sowing of pulses with Happy Seeder

In use of Happy Seeder Technology, the burning of residues is eliminated paving a way to sustainable agriculture**.** In the combine harvested paddy field, direct sowing of pulses by Zero- Till Happy Seeder is done without any tillage operation or seedbed preparation at standard row spacing of 9 inches. The leftover anchored straw is to be managed by straw management rotor which is surrounded by flail blades around its periphery. Sowing of pulses with Happy Seeder is shown in Plate 3.11

Plate 3.11 Sowing of pulses by Happy Seeder

3.4 ADVANTAGES OF HAPPY SEEDER TECHNOLOGY

1. Best solution for paddy residue management after combine operation.
2. Most of the paddy residue is retained and seed is sown in a single pass.
3. This technology is environment-friendly for maintaining soil health and crop output.
4. Also conserves moisture because of paddy stubbles acting as mulch cover over thesown crop.
5. Excludes the practice of burning residues before sowing which reduces in turn reduces air pollution.
6. Savings of time, energy, water and tillage operations in comparison with traditional methods.

3.5 DRAWBACKS OF HAPPY SEEDER TECHNOLOGY

Stubble management through Happy Seeder leaves behind much paddy residues which cannot be ploughed back into the soil which creates disturbance for sowing and germination. The clogging of soil along the straw residues around the straw management rotor makes the performance of flail blades inefficient. The anchored straw residues cannot be completely removedby Happy Seeder. Lack of furrow closers in the Happy Seeder results in incomplete covering of furrows leading to improper germination.

3.6 BRIEF DESCRIPTION OF HAPPY SEEDER

Happy Seeder is a machine which is used for direct sowing of seeds in the stubbles of paddy residue without any tillage operation. It is called “happy” because the time gap between harvesting paddy and sowing of next crop is reduced. The cost of cultivation is less compared to conventional method of burning stubbles. Apart from these, there are many advantages of using this technology, one of which is no tillage operations, saving of two irrigations, moisture conservation etc. It consists of straw management drum which is surrounded by flail blades in front of furrow openersin order to cut the loose straw left over by the combine harvester.

The loose straw is uniformly covered on the sown seeds as moisture conserver. Happy seeder works as rotovator and seed drill, which former works as tillage implement whereas latter for sowing operation. This technology is used byfarmers of India to combat with the problems faced by the air pollution and accumulation of carbon footprints. The Happy seeder technology has been recognized as a significant innovation for in- situ residue management because of its ability to directly sow second crop in loose and anchored straw loaded up to 10 t ha^{-1}. The technology reduces preliminary burning of residues which results in decrease of environmental pollution and improves soil health .The loose straw which is remained after the harvesting of paddy using combine harvester acts as surface mulch for the next crop, thus helps in moisture conservation. The Zero-Till Happy Seeder used in the study is presented in Plate 3.12.

Plate 3.12 Zero-Till Happy Seeder

3.7 SALIENT FEATURES OF HAPPY SEEDER

1. Used for sowing of wheat, sorghum, maize, barley, pulses in the residue of previous crops. The machine is equipped with straw managing chopper which enable the seeding in the straw itself. When this straw decay on the soil as mulch layer it increasesthe fertility of soil.
2. Superior quality steel furrow openers gives long wear resistance.

3. Narrow seed or fertilizer placement boots ensures minimum soil disturbance in zero- tillage seeding.
4. Heavy duty construction with best quality raw material used.
5. All the components and parts are manufactured by latest technology like CNC machines, MIG welding which ensures parts interchangeability, enhanced product life, precise and reliable working.
6. Better surface finish after cleaning, shot blasting under coat and then painting with PU top to all the components before assembling to ensure the users for having long corrosion freeproduct life.
7. Tines fitted with U clamps for easy adjustments along with strong grip.
8. Very easy to adjust Seed and Fertilizer rate by fluted roller mechanism.
9. Gun metal bushing in load bearing depth control wheels to give long wear free service life.
10. Better quality and durable components were used for chain and sprocket system, fluted rollers, spring loaded idlers and fasteners.

3.8 REASONS FOR THE ADOPTION OF HAPPY SEEDER IN KRISHNA ZONE

In the Krishna zone, the traditional practice of pulse sowing after paddy harvesting is broadcasting of the seeds i.e. random scattering of seed on the surface of seed beds which increases the seed rate and the plant density per unit area which leads to competition for nutrient and vitamin supplements. It can be done manually or mechanically. With this method, there are many drawbacks like higher seed rate, higher weed growth and unwanted crop growth. The variation in seed distribution is varying over the entire field and it is unable to maintain uniform plant to plant and row to row spacing.

Even today, the farmers are burning the crop residues especially paddy in south India which leads to air pollution and it has a bad impact on people's health and regional climate and crop output. The present available Happy Seeders to be developed with suitable furrow closers to deposit the residue content of paddy and left over from the farm over the sown area. This method of sowing pulses into the harvested paddy fields helps to conserve water, labour, time, and cost of operation and reduces hazardous impacts on the environment.

3.9 Major Components of Happy Seeder

The major components of Happy Seeder are described in the following sections.

1. Frame

The frame holds all the parts attached to the happy seeder which is made up of mild steel. The mild steel angle iron welded together constitutes the frame. Tynes are attached to the frame through U clamps. The frame of the Zero-Till Happy Seeder is givenin Plate 3.13

Plate.3.13 Frame

2. Furrow openers

Straight inverted T tynes are used as furrow openers to open the soil at some depth for sowing seed and fertilizer. It creates furrow groove with reduced surface exposure and thereby helps to maintain the in-groove humidity in a reasonably wet soil for better germination and emergence of seedlings. The seed and fertilizers dropped in the seed delivery pipes are passed through boots and finally placed in the silts opened by furrow openers. The furrow openers of Zero-Till Happy Seeder is given in the Plate.3.1.

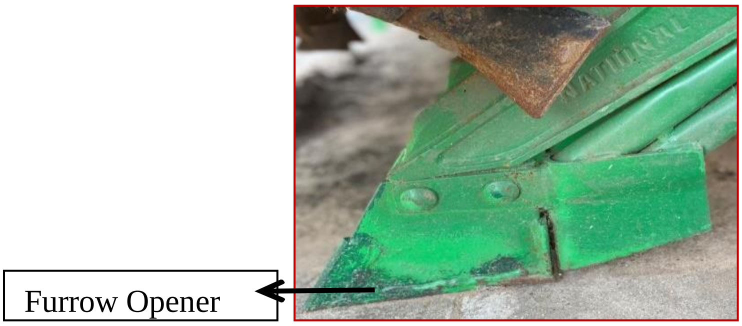


Plate 3.14 Furrow opener

3. Flail blades

Flail blades are the important components of Happy Seeder and are used to cut the anchored straw leftover in the combine harvested field and covers as surface mulch on the field in order to conserve moisture. These blades are in the form of inverted gamma shape which is the modified form of Y type blade earlier. Flails are made of mild steel and attached around the periphery of rotary shaft driven through the PTO. This assembly of flail shaft, flail blades and encapsulated cover is called straw management system. The performance of flail blades is of prime importance for the efficient working of happy seeder. The flail blades located on the periphery of straw management rotor is given in the Plate 3.15

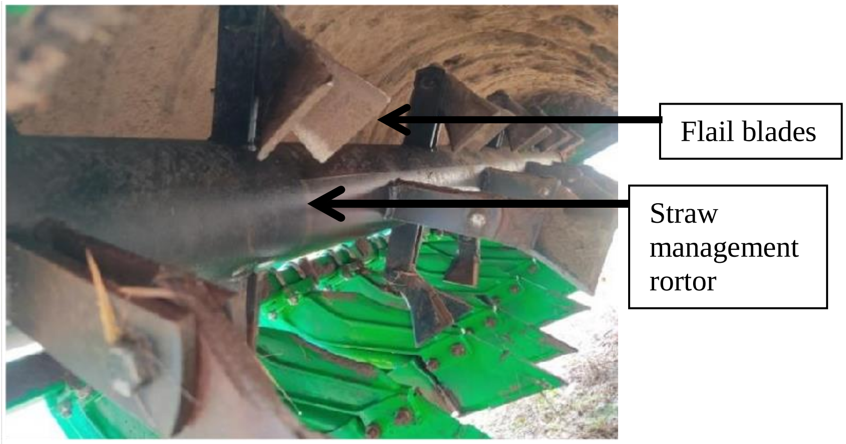


Plate 3.15 Flail Blades around the straw management rotor

4. Seed and fertilizer boxes

Trapezoidal section seed and fertilizer boxes made of mild steel are used in happy seeder .Seed box is mounted at rear of the machine whereas fertilizer at the front side. The Seed and fertilizer boxes of Zero-Till Happy Seeder are given in Plate 3.16.

Plate 3.16 Seed and fertilizer boxes

5. Fertilizer metering mechanism

This mechanism is used to meter the fertilizer at a predetermined rate during the field sowing operation. The roller fitted on the shaft makes the fertilizer to pass into the seed box. The open area present will allow the seeds to flow into the seed pipe which enters into slits made by furrow openers.

6. Seed metering mechanism

Seed metering mechanism consists of following components ;

1. Fluted rollers
2. Seed tube
3. Seed adjustment lever
4. Seed rate adjustment lever

1. Fluted rollers

The fluted rollers are most commonly used seed metering mechanism in seed drills andHappy Seeders which is driven by the ground wheel with the help of chain and sprocket drive. As the drive shaft and fluted rollers rotate, the seed is carried to the furrow openers through the delivery pipes. The fluted rollers of Happy Seeder are given in Plate 3.17.

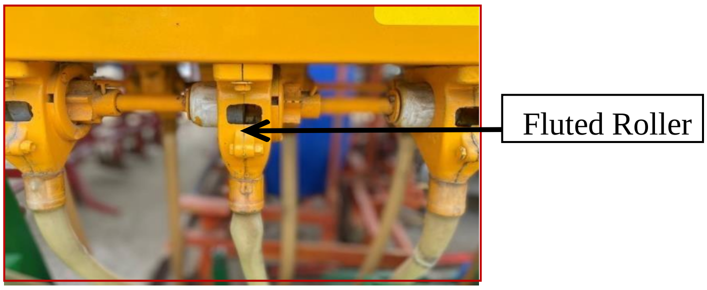


Plate 3.17 Fluted roller

2. Seed tube

Seed tubes are used for delivering of seeds into the boot to furrow openers. These tubes are made up of transparent PVC material. The seed and fertilizer tubes of Happy Seeder are given in Plate 3.18.

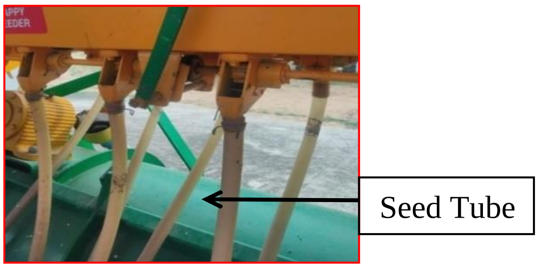


Plate 3.18 Seed tube

3. Seed rate adjusting lever

This type of lever is used to adjust the seed rate. A scale is provided which helps in increasing or decreasing the quantity of seed flowing into the pipes. The seed rate adjusting lever of Happy Seeder is given in Plate 3.19

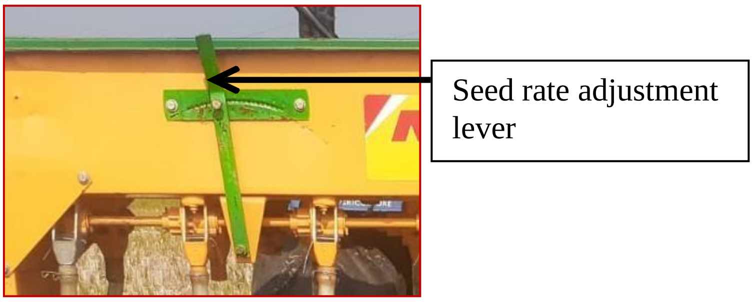


Plate 3.19 Seed rate adjustment lever

4. Fertilizer rate adjustment lever

This type of lever is used to adjust the fertilizer rate. A curved scale with marked numbers is present to decrease or increase the rate of fertilizer dropping into the pipes. The fertilizer rate adjustment lever of Happy Seeder is given in Plate 3.20

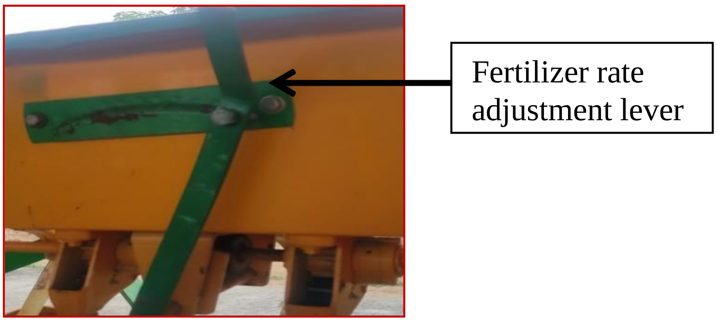


Plate 3.20 Fertilizer rate adjustment lever

7. Gauge Wheel

Gauge wheel is used for depth control with jack-type adjustment to maintain uniform depth at various undulations in the field due to soil clods. The Gauge wheel of Happy Seeder is given in the Plate 3.21

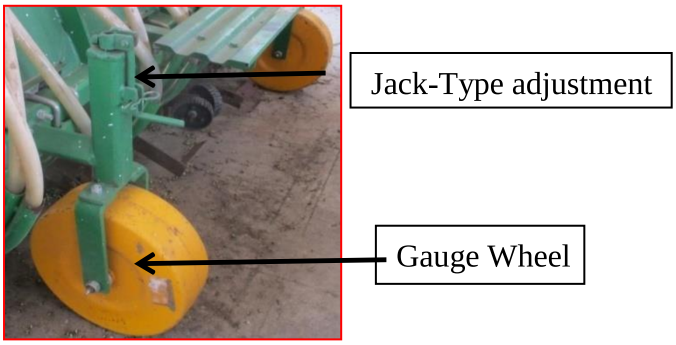


Plate 3.21 Gauge Wheel

8. Power Transmission System

There are two types of power transmission in Zero-Till Happy Seeder i.e. by Power transmission by PTO Shaft of tractor and Power transmission of seed metering mechanism by ground wheel

1. Power transmission by PTO Shaft of tractor

The power transmission system by the PTO shaft provides drive to the flails situated in the periphery of straw management rotor. The Power take off shaft is first attached to the gear box which is used for speed reduction from 540 rpm to 210 rpm of rotor.

There is a drive shaft in the machine which provides the drive to the drive pulley. A beltjoins the drive to the PTO drive pulley to the flail drive pulley which rotates the flail shaft and hence, the flails get drive from PTO shaft and start to rotate. The line diagram of power transmission through PTO shaft to the straw management rotor is given in Fig.3.4

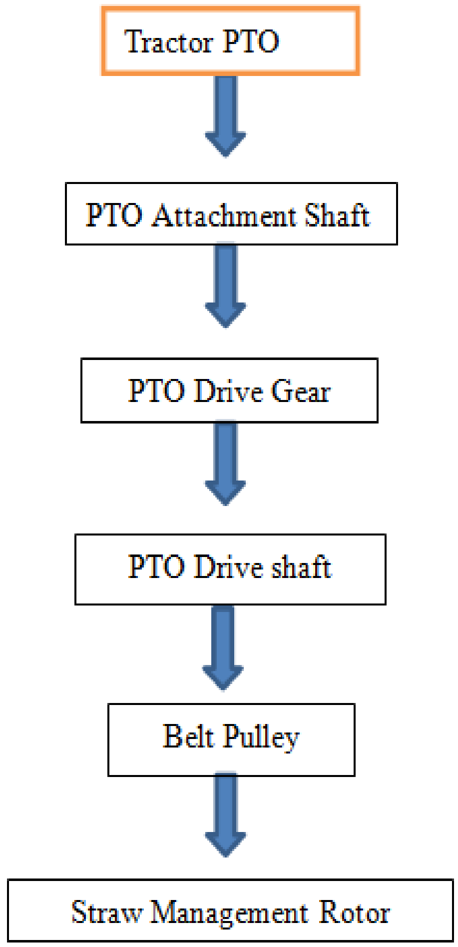


Fig 3.4 Line diagram of power transmission system by PTO

2. Power Transmission by Drive Wheel

Drive wheel provides necessary power to meter the seed and fertilizer metering mechanism. As the drive wheel rotates, the chain mechanism starts to move through driving and driven shafts. The chain rolls over the seed and fertilizer sprockets/gear. These sprockets or gears rotate the seed and fertilizer shafts. As the seed and fertilizer shaft rotates, the fluted rollers start to work and the seed and fertilizer are delivered into pipes. There is flip gate which can be opened to apply oil or grease to the chain whenever necessary. The line diagram of power transmission through drive wheel is given in Fig 3.5.

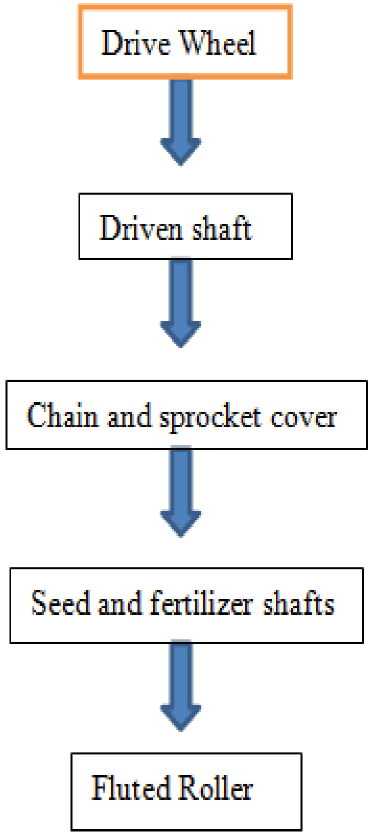


Fig 3.5 Line diagram of power transmission system by drive wheel

8.1 Components of Power Transmission System of Seed metering mechanism

Power transmission system of Zero-Till Happy Seeder includes ground wheel, chainand sprocket system as a means of transmitting power to meter seed and fertilizer shafts and universal joint, PTO gear box and belt pulley to provide drive for straw management rotor. The main components of power transmission system of seed meteringmechanism and straw management rotor are given below;

1. Ground Wheel

The overall performance of Happy Seeder depends upon the functioning of drive wheel. It's function is to transmit power to the seed and fertilizer metering mechanism through chain and sprocket transmission system. Lugs are present on the periphery of drive wheel to prevent slip and to count the number of revolutions in the field during sowing operation.

The drive wheelof happy Seeder is given in the Plate 3.22.

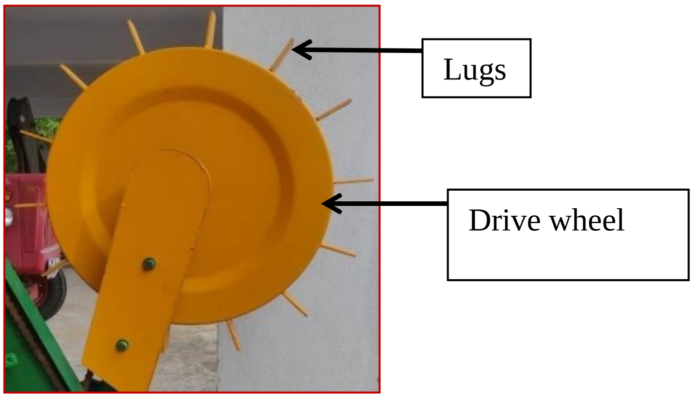


Plate 3.22 Drive wheel

2. Chain and sprocket transmission system

Through chain and sprocket arrangement, drive is given to the fluted roller which is commonly used seed metering mechanism in Happy Seeder. The chain and sprocket transmission system of Happy Seeder is given in the Plate 3.23

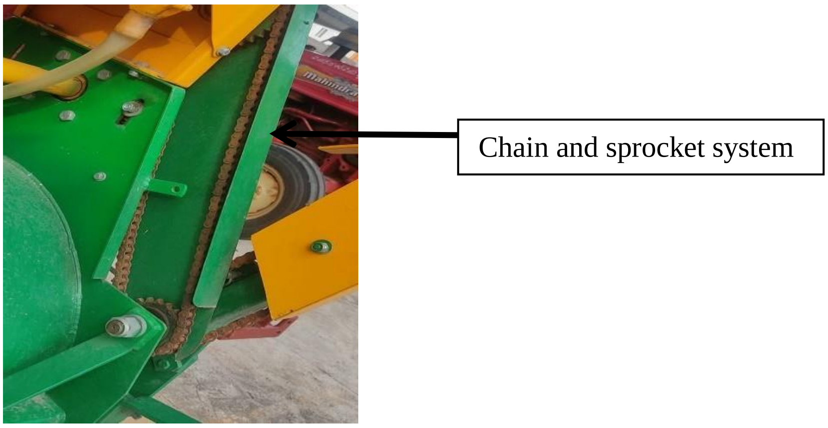


Plate 3.23 Chain and sprocket system

3. 3-Point linkage

Three point linkages are attached to the power-take off shaft of the tractor. It consists of three links i.e. one upper and two lower to which tension and compression links are attached using adjusting pins. The 3-Point linkage of Happy Seeder is given in the Plate 3.24

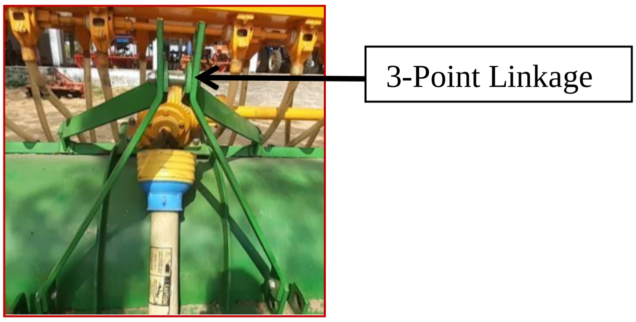


Plate 3.24 Three point linkage

4. PTO Attachment Shaft

The maximum power is available at the power take-off shaft. It consists of two hook joints and a telescopic shaft or cardon shaft enabling it to rotate freely when in varying angular relation to another shafts to which it is joined whose one end is connected to the bevel gear arrangement unit of the implement and other is connected to the PTO of the tractor which has a universal joint at one or both ends enabling it to rotate freely when in varying angular relation to another shafts to which it is joined. The universal joint of Zero-Till Happy Seeder is given in Plate 3.25

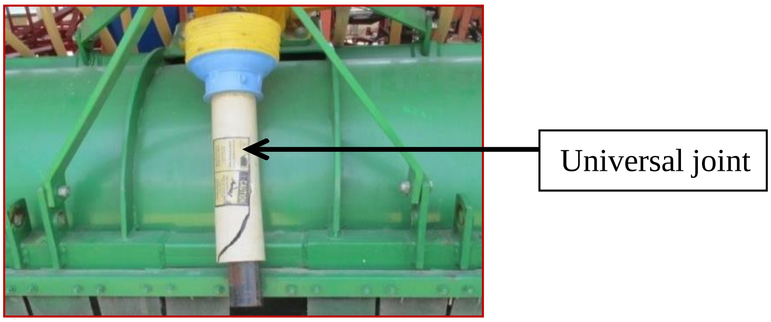


Plate 3.25 Universal Joint

The specifications of Zero-Till Happy Seeder used in the present research study are given in APPENDIX-A

3.10 WORKING OF HAPPY SEEDER

Happy Seeder is a tractor mounted implement hitched by three point linkage which cuts and lifts rice straw, sow's seed into the soil without any prior seedbed preparation and deposits the straw over the sown area as mulch. It is operated with the PTO which is mounted to the three point linkage which gives drive in two way speed reduction unit. Here, power is transmitted by two- way reduction i.e.

1. Primary reduction unit

The main function of this unit is to transmit the tractor power to the secondary speed reduction unit and to reduce standard PTO rpm (540 rpm) approximately to about 60% i.e. 210 rpm. In general, bevel gears are used in the primary speed reduction unit. These are made from high strength carbon steel.

2. Secondary reduction unit

This unit is also known as side drive and it transmits the tractor PTO power to the rotor shaft. This unit consists of chain and sprocket assembly. It is a combination of Rotovator and Zero-till drill. It consists of straw management drum which cuts the loose straw to length of 8-10 cm to which the drive is given from and makes it possible to sow new crop in the combine harvested paddy field. This drum has a cover which acts as a safety feature. It is mostly used in the paddy harvested fields to manage the residues left over in the field. Seed metering mechanism used was fluted roller

3.11 DRAWBACKS OF HAPPY SEEDER TECHNOLOGY

Stubble management through Happy Seeder leaves behind many paddy residues which cannot be ploughed back into the soil which creates disturbance for sowing and germination. The anchored straw residues cannot be completely removed by Happy Seeder. Lack of furrow closers in the Happy Seeder causes incomplete covering of furrows leading to improper germination.

3.12 NEED FOR FURROW CLOSERS

Appropriate residue management is a key factor for successful crop establishment in no- tillage systems. Satisfactory opening and closing of furrows and uniform seeding depth and seed spacing are achieved when the design of the residue management unit of the seeder and machinery settings are correctly selected for the soil type, soil condition and soil surface residue characteristics. Main reasons behind this need is to increase the seed-soil contact for better germination, conserving moisture for seed, preventing birds from eating away seeds, to reduce the disturbance caused by human activities. Improper selection of such units or settings can result in blockage of furrow openers with accumulated residues and hair pinning when disc openers are used. This can effect seed-soil contact and result in uneven seedling emergence or sub-optimal plant stand, and reduce crop yield potential.

3.12.1 Development and Fabrication of Furrow Closers

As there is a need of furrow closers for present Zero-Till Happy Seeder because the seeds which are sown are not covered properly which leads to low germination percentage of seeds and there is risk of birds eating the seeds or any other manual activity which disturbs the seed. Hence, the fabrication of furrow closers using simple available materials was done in Dr.M. V. Rao Workshop at Dr.NTR College of

Agricultural Engineering, Bapatla.

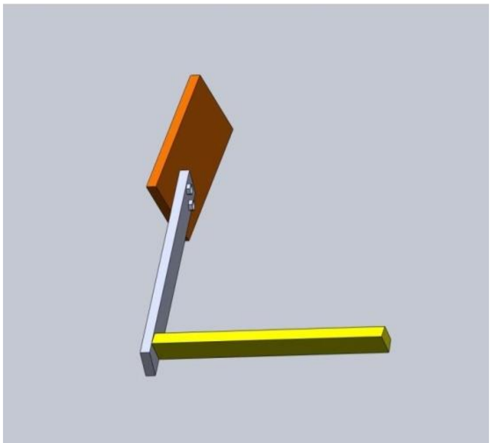
3.12.2 Different Types of Furrow closers

Different types of furrow closers were developed and fabricated in the M.V.Rao workshop at Dr. NTR College of Agricultural Engineering, Bapatla. The seed being uncovered during sowing by Zero-Till Happy Seeder have been creating problems like seeds being pickedby birds or disturbed by manual activities during farm operations. To address this problem, furrow closers need to be developed and attached at rear of furrow openers of Happy Seeder.

3.12.2.1 Development of furrow closers

1. L-type blade with 30° inclination

L-Type blade with 30° inclination was fabricated using mild steel and was welded together by Arc-welding. Horizontal and vertical blade was fabricated and welded together at an inward angle inclined at 30 degree so that the horizontal blade would carry the soil and throw the soil on uncovered furrows for better seed-soil contact to get good germination. The CAD view of L-type blade at 30° inclination furrow closer is given in Fig 3.6.



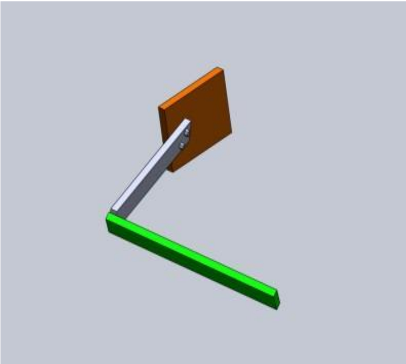
(a) **(b)**

(a) CAD view **(b) Developed view**

Fig.3.6 CAD view and developed view of L-Type blade with 30° inclination

2. L-Type blade with 120° inclination

L –Type at 120° inclination was fabricated using mild steel and was welded together by Arc welding. Horizontal and vertical blade was fabricated and welded together at an inward angle inclined at 120° so that the horizontal blade would carry the soil and throw the soil on uncovered furrows for better seed-soil contact to get good germination. The CAD view developed for L-type blade at 120° inclination is given in Fig 3.7.



(a)

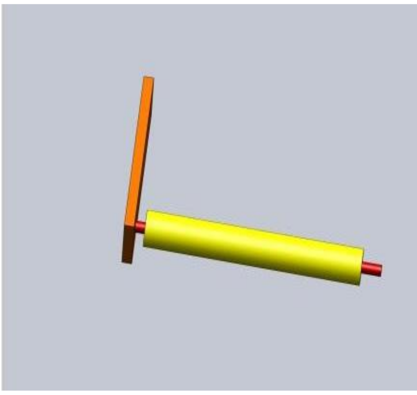
(b)

(a) CAD View **(b) Developed view**

Fig.3.7 CAD view and developed view of L-Type blade with 120° inclination

3. Roller Type

Roller type furrow closer was fabricated using mild steel. A cylindrical shaft of inner diameter 1.5cm and 3cm outer diameter was fabricated such that it has rolling action. The shaft was attached to the vertical blade by drilling a hole. This increases the seed- soil contact to get better germination. The CAD view and developed view of roller type furrow closer is given in Fig 3.8.



(a)

(b)

(a) CAD view **(c) Developed view**

Fig 3.8 CAD view and developed view of Roller type furrow closer

4. Double Wheel Type

Double Wheel type furrow closer was fabricated using two round fibre wheels set at an angle to each other and fitted together to work as furrow closer to cover the seed placed in furrow. The CAD view and developed view of Double wheel type furrow closer is given in Fig.3.9.

(a)

(b)

(a) CAD view **(b) Developed view**

Fig 3.9 CAD view and developed view of Double Wheel type

3.13 TESTING OF HAPPY SEEDER UNDER LABORATORY CONDITIONS

1. Seed Metering Test

The Happy Seeder is tested for the recommended seed rate per hectare and the probability of seed damage in operating condition. The calibration procedure of Happy Seeder is given below:

Calibration of Happy Seeder is done to find the seed and fertilizer rate prior to sowing.to know the quantity of seed sown in the field.

1. Jacked up the Happy Seeder and check the free rotation of driving wheel and seed and fertilizer feed-shafts.
2. Placed a container or polythene bag under each furrow opener.
3. Measured the circumference of the driving wheel. The circumference gives the distance covered in one revolution of wheel of Happy Seeder
4. Find out the size of machine by multiplying the number of furrow openers with the spacing between the furrow openers.
5. Find out number of revolutions required to plant one acre area as follows:

Number of revolutions = $\frac{Area\ in\ acre\ (4000\ m^2}{Size\ of\ machine(m) X\ Circumference\ of\ driving\ wheel(m)}$

Multiply this by 9/10 to take care of wheel skid in the field

6. Marked a point on the rim of wheel. Rotate the wheel by 1/10th of the number of revolutions required to plant one acre. Collected the seed from each pipe and weigh it.
7. For getting seed rate per acre, multiply by 10.
8. Adjust the shift lever on the feed box for seed rate accordingly, i.e. if the seed rate seems to be less than the actual quantity required per acre, and then move the indicator a little to the higher side or vice-versa.
9. If the quantity collected from each furrow opener is not uniform, then check for defect in seed dropping mechanism.

Similarly, calibrate the machine for the fertilizer dose. The Happy seeder is attached to the tractor through a three point linkage.

The calibration of Happy Seeder under laboratory conditions is shown in Plate 3.26. The experiment was repeated thrice and mean value was calculated.

Plate 3.26 Laboratory testing of Happy Seeder

2. **Type of soil**

The type of soil selected for the study was sandy loam, clay loam, and sandy soil which are mostly available in the Krishna zone. The fields selected for testing of Happy Seeder is shown in Plate 3.27.

(a)

(b)

(c)

(a) Sandy; (b) Black; (c) Clay loam

Plate 3.27 Selected Fields for Testing of Happy Seeder

3.14 MEASUREMENT OF PHYSICAL PROPERTIES

1. Moisture Content of Soil

Soil samples were collected at six different locations randomly selected in the field at a depth of 25cm. The selected soil sample should be free from dust and other crop residues. The initial weight of the container and known weight of soil were taken and was oven dried in Biohall hot airoven at 105°c for 24 hours. The final weight of the oven dried sample was weighed and the difference between the initial and final weights was recorded. The collected three soil samples and oven used for measurement of moisture content is given in Plate 3.28.

(a) **(b)**

(a) Collected soil samples (b) Biohall oven

Plate 3.28 Moisture content determination of black, clay loam and sandy soil

The soil moisture content on dry basis (%) was calculated using the following expression.

$$M.C\ (\%\ d.b) = \frac{W1-W2}{W2} \times 100 \qquad \ldots(3.1)$$

where,

w_1 = weight of container + initial soil sample, g

w_2 = weight of dried sample, g

2. Moisture Content of Straw

Paddy straw residues were taken from six different locations from the paddy harvested field. The selected residue samples should be free from soil content. These samples are weighed in six different aluminum containers and oven dried at 105°c for 24 hours in Bio hall hot air oven.The weight of the dried samples was recorded and the difference between initial and final weight of the container was recorded. The collected paddy straw sample is given in Plate 3.29.

Plate.3.29 Collected Paddy straw samples

The moisture content of collected paddy straw samples from different locations was measured by the formula in the equation 3.2.

$$M.C\ (\%\ dry\ basis) = \frac{W1-W2}{W2} \times 100 \qquad ..(3.2)$$

where,

M.C (% d.b) = Moisture Content (% dry basis)

w_1 = weight of container + initial straw sample, g

w_2 = weight of dried straw sample, g

3. Moisture Content of Seeds

Three different grains namely black gram, green gram and maize were taken in differen containers before sowing. The initial weight of the container and known weight of grains were taken and was oven dried in Biohall hot air oven at 105°c for 24 hours. The final weight of the oven dried samples was weighed and the difference between the initial and final weights was recorded. The collected seed samples namely black gram, green gram and maize are given in Plate 3.30.

Plate 3.30 Seed samples of black gram, green gram and maize

The moisture content of collected paddy straw samples from different locations was measured by the formula in the equation 3.3

$$M.C\ (\%\ d.b) = \frac{W1-W2}{W2} \times 100 \qquad ..(3.3)$$

where,

M.C (% d.b) = Moisture Content (% dry basis)

w_1 = weight of container + initial seed sample, g

w_2 = weight of dried seed sample, g

3.15.3 Bulk Density of Soil (ρ_b)

Soil bulk density is the mass of dry soil per unit of bulk volume, including the air space. Bulk density of clay loam, sandy loam soil and sandy soil was calculated by taking the soil samples from six different locations in the field. The field density of soil is obtained from direct measurements using the core cutter method. In this method, known volume and weight of the double cylindrical core sampler was taken to remove the cylindrical core of soil.

The sampler head contains an inner cylinder and is driven into the soil. The inner cylinder containing an undisturbed soil core is then removed and trimmed to the end with a knife to yield a core whose volume can easily be calculated from its length and diameter. Before lifting the core cutter, soil around the cutter should be removed to minimize the disturbance. The weight of this soil core is then determined after drying in an oven at 105°C for about 18-24 hours. Bulk density measurement by core cutter method in different soils is given in Plate 3.31.

Plate 3.31 Determination of Bulk density by Core cutter method

Bulk density is calculated by the given formula;

$$\rho_b = \frac{Ms}{Vs} \qquad \text{….(3.4)}$$

Where,

ρ_b = Bulk density of soil, g/cm^3

M_s = Mass of soil sample. g

V_s = Volume of soil sample, g

3.16 SEED GERMINATION

Seed germination constitutes the very basis of optimum plant stand, which ultimately account for the crop yield. Therefore, germination count may be considered as a fair predictor of final plant population. Plant germination (plants that had emerged through the soil) was noted at 10 DAS (days after sowing). The number of seedlings per meter row length in 5 adjacent rows was recorded in each plot and their average value was calculated, and then converted to number of plants per square meter area for all treatments.

3.16.1 GERMINATION TEST

Germination of seeds is a deciding factor for farmers for optimizing better yield of the crop. Therefore, it is necessary to identify the germination percentage of seeds under lab conditions priorto sowing. This test is done to know the information about seed germination rate which can be helpful to farmers while planting.

3.16.1.1 Procedure for Germination Test under Laboratory Conditions

3.16.1.1 Sampling

To obtain a random sample for testing, it is always best to take samples from different parts of the bag or container. Three different samples of seeds like Black gram, Green gram and Maize were collected.

3.16.1.2 Equipment

To conduct this test, the following things are needed;

1. Water proof tray
2. Water-absorbent material like tissue or cotton wool is ideal.
3. Seeds: Black gram, Green gram and Maize
4. Water

3.16.1.3 Procedure

1. Water-absorbent material was placed inside the water proof tray.
2. Then random seed samples from each seed lot were taken.
3. 100 seeds were taken from each sample and placed on absorbent material inside the tray.
4. For pulses like Black gram and Green gram, germination rate was checked after 1 day, and for cereals like Maize after 4 days to see that the absorbent material remains moist and to record the number of germinated seeds.

5. Finally, germination percentage was calculated after 1 day (24 hours) for pulses and 4 days for cereals.

3.16.1.4 Calculation of germination rate

Germination rate is the average number of seeds germinated to the total number of seeds in a seed lot over a period of 24 hours.

$$\text{Germination Percentage} = \frac{\text{Number of seeds germinated}}{\text{Total number of seeds on the tray}} \times 100 \quad \text{....(3.5)}$$

The germination rate of Black gram, Green gram and maize is given in Plate 3.32

(a)

(b)

(c)

(a) Green gram; (b) Black gram; (c) Maize

Plate 3.32 Germination of seeds under laboratory conditions

3.8. FIELD EVALUATION

The three types of crops taken for the study were Black gram, Green gram and Maize for field evaluation in three different types of soil.

3.8.1 Evaluation of Happy Seeder in Different Types of Soil

The soil parameters of the experimental plot such as soil type, moisture content and bulk density were evaluated. Three crops were selected for the study i.e. Black Gram, Green Gram and Maize.

3.9 Testing and Evaluation of Happy Seeder

The following parameters were noted during the field evaluation. The Happy Seeder was operated in an area of 0.29 hectare of each type of soil. New Holland 4710 model tractor was used for the evaluation of Happy Seeder and the specifications of test tractor is given in Appendix-B. The test was conducted in the research farm of Dr. NTR College of Agricultural Engineering, Bapatla. The following parameters were observed during the field evaluation.

1. Actual working width, m
2. Ground wheel slip, %
3. Draft, N
4. Fuel consumption, l h^{-1}
5. Operating Speed, km h^{-1}
6. Theoretical Field capacity, ha h^{-1}
7. Actual Field capacity, ha h^{-1}
8. Field efficiency, (%)
9. Power requirement, (Hp)
10. Speed Index

3.9.1 Actual Working Width

The working width of Happy Seeder is obtained by multiplying the number of furrow openers with the distance between two consecutive furrow openers. The actual working width of the Happy Seeder is obtained by the following equation 3.1.

Where,

$$W = N \times D \qquad \ldots.(3.1)$$

W=Actual working width, m

N=Number of furrow openers

D= Spacing between two consecutive furrow openers, m

3.9.1 Ground Wheel Slip

The number of revolutions of the ground wheel for a distance of 25 m travel by the Happy Seeder was recorded. The implement was first operated with no load at a depth of 1cm and with load condition at a depth of 6-7cm and the number of revolutions taken to cover the distance of 25 m was recorded. The markings were done by dark coloured chalk piece on the lugs and ground wheel to count the number of revolutions. The slip was calculated in three different types of soil namely sandy, clay loam and black as shown in Plate 3.33 using the following equation 3.2.

$$Sg = \frac{N1-N2}{N1} X100 \qquad \ldots.(3.2)$$

Where,

S_g=Ground Wheel Slip, %

N1= Number of revolutions of ground wheel with load, m

N2= Number of revolutions ground wheel without load, m

Plate.3.33 Measurement of Ground wheel slip

3.9.2 Draft Force

The draft of the Zero-till Happy Seeder was measured by hitching the Happy Seeder to an auxiliary tractor through a S-Type load cell dynamometer of 3 ton capacity which was attached to the front of the tractor. Draft with no load was calculated without attaching Happy Seeder for a distance of 20 m and list of spontaneous values of draft force displayed on the load cell were recorded and the average was taken and multiplied by 9.81 to convert the draft force intoNewton.

The same procedure was applied to measure the draft with load i.e.by hitching the Happy Seeder. The draft force will vary according to the soil conditions over the entire field. The draft was measured for three different types of soil namely Sandy loam, sandy and clay loam soil. The difference of readings with and without load indicates the draft requirement to pull the implement. Measurement of draft of Happy seeder using S-tpe load cell is shown in Plate 3.34.

Plate.3.34 Draft force measurement

3.9.1 Fuel Consumption

For measuring the fuel consumption, top fill method was employed. Initially, the tank is filled up to maximum capacity, and then the tractor is operated for an hour. The fuel consumed was filled using a measuring jar. The difference in the volume of fuel in the measuring jar before and after the operation gave the volume of fuel consumed per hour. The fuel consumption in three different fields with different soils was measured using same procedure. The measurement of fuel consumption of Happy Seeder is given in Plate 3.35.

Plate 3.35 Measurement of fuel consumption

3.9.2 Operating Speed Measurement

Tractor was operated at 1500 rpm at L-2 gear to measure the operating speed in three different soils. It was measured by taking the time to cover adistance of 20m in a unit time using stopwatch.

Table 3.8 Operating Speed in different types of soil

Type of soil	Operating Speed, km h^{-1}
Sandy loam	1.5
Sandy	1.6
Clay loam	1.47

3.9.3 Theoretical Field Capacity

The number of acres or hectares actually covered over a long period of time includingtime lost in turning and fuel filling. Effective field capacity brings in the factor of efficiency. This capacity determination represents the real life or actual capacity obtainable over a period of time. The spacing between two adjacent furrow openers was measured. Effective width of the machine was computed and theoretical field capacity (ha h^{-1}) was calculated using equation 3.3

$$\text{TFC (ha h}^{-1}\text{)} = \frac{wxs}{10} \qquad \ldots(3.3)$$

where.

TFC = Theoretical field capacity, ha h^{-1}

W = Effective width of machine, m

S = Speed of operation. Km h^{-1}

3.9.4 Effective Field Capacity

Effective field capacity is the maximum possible capacity obtainable at a given speed, assuming the machine using its full width. It is a function of the rated width of the machine, the percentage of rated width actually utilized, speed of the travel and the amount of field time lost during the operation. It is expressed in hectare per hour. It depends on two factors namely speed and width. It is calculated by using the below equation 3.4.

$$EFC\ (ha\ h^{-1}) = \frac{A}{Tp+Tnp} \qquad \ldots (3.4)$$

Where,

EFC = Effective Field Capacity, ha h^{-1}

A = Area of coverage, ha

Tp = Productive time, h

Tnp = Non-productive time, h

3.9.5 Field Efficiency

Field efficiency (F_e) is the ratio of effective field capacity to the theoretical field capacity and is expressed in %.It includes the effect of time lost in the field and failure to utilize the full width of the machine. Field efficiency was calculated by using equation 3.5.

$$F_e\ (\%) = \frac{EFC}{TFC}\ x\ 100 \qquad \ldots (3.5)$$

Where,

F_e = Field efficiency, (%)

EFC= Effective Field Capacity, ha h^{-1}

TFC= Theoretical Field Capacity, ha h^{-1}

3.9.10 Power Requirement of Happy Seeder

The power requirement for mounted implement i.e. Happy Seeder in three different typesof soil was calculated using the formula 3.6.

$$P = \frac{DXS}{75} \quad \text{...(3.6)}$$

P = Power requirement, Metric hp

D = Draft, kgf

S = Speed of operation, m s^{-1}

3.9.11 Wheel Slip of Tractor

Tractor drive wheels normally slip in all field operations such that the distance coveredby the tractor in a given number of drive wheel revolutions decreases with the wheel slip. Distancetravelled by the tractor in the field with and without load (machine), in four revolutions of the drivewheel was measured. Wheel slip of tractor operated Zero-Till Happy seeder was then calculated by the following equation 3.7.

$$S= \frac{D1-D2}{D1} \times 100 \quad \text{...(3.7)}$$

Where,

S = Wheel slip of tractor, %

D1= Distance covered without load, m

D2 = Distance covered with load, m

3.9.12 Speed Index

The tractor engine was run at different engine speeds from 1500-2400 rpm while the PTO was engaged. A digital tachometer was used to measure the rpm of the machine rotor at these different engine speeds and the observations were noted down. The combinations of engine and rotor speeds in which machine operated smoothly without choking during the preliminary tests were selected for field trials. Forward speeds of operation corresponding to engine rpm and different forward gears (A1 and A2) were selected.

Speed index was expressed as the ratio of tractor forward speed and rotor speed. Three speed indexes selected for trials were R1, R2 and R3, ratio of forward speed and rotor speed R2 (Alekshey *et al*.,2020). The performance of flail blades in the straw management of machine mainly depends on speed index which is defined as the ratio of forward speed to the rotor speed. Speed Index was measured in different types of soil i.e. Sandy loam, clay loam, Sandy soil. It varies from soil to soil. Forward speed of the tractor is taken and the rotor speed is measured using tachometer. Measurement of rotor speed by analog type tachometer is given in Plate 3.36.

Plate 3.36 Measurement of rotor speed by Analog Type Tachometer

The speed index was calculated by the formula given in equation 3.8.

$$\text{Speed Index} = \frac{Forward\ speed}{Rotor\ speed} \quad \ldots(3.8)$$

Where,

Forward speed = Operating speed of tractor, km h^{-1}

Rotor speed, km h^{-1}= 0.1885 x wheel speed (rpm) x rim diameter

3.10 STUDY OF DIFFERENT CROP PARAMETERS IN THREE DIFFERENT TYPES OF SOIL

The crop parameter play a significant role. The crop parameters considered in the sowing of black gram, Green gram and Maize using happy seeder in three different soils were as follows

1. Machine Parameters

I. Operating speed (km h^{-1})
II. Seed rate (kg ha^{-1})
III. Row spacing (cm)
IV. Furrow width (cm)
V. Depth of operation (cm)

2. Crop Parameters

I. Germination holes
II. Plant to plant spacing (cm)
III. Plant height (cm)

1. Black gram

Black gram (Vigna Mungo L.) is one of the important pulse crop mostly grown in southern part of India which is generally consumed in the form of 'Dal'. It is the chief constituent of papad,idly and dosa in the southern India. For milch cattle it is used as nutritive fodder and also used as green manuring crop. It is a short duration crop with a crop period of 60-70 days. It controls soil erosion and compete with weeds effectively due to its deep root system and foliage cover. It contains protein (25%), carbohydrates (60%), fat (1.3%) and rich in phosphoric acid. It fixes atmospheric nitrogen into soil and improve the soil fertility. Black gram was sown in clay loam soil with the help of Happy seeder as shown in Plate 3.37 (a) and closed view of black gram in fluted roller is shown in Plate 3.37 (b).

(a) **(b)**

(a) Sowing of black gram; (b) Closed view of black gram in fluted roller

Plate 3.37 Sowing of Black gram in clay loam by Happy Seeder

2. Green gram

Mung bean (*Vigna radiata* L.) which is alternatively known as green gram or moong. It isa leguminous plant crop mainly grown in east, Southeast and South Asia. It is used as a major ingredient in savoury and sweet food products. The plant height varies from 15 to 125 cm and hasa tap root system which contains root nodules. The seeds take generally 4-5 days to germinate andcrop maturation take almost 60 days. Green gram contains about 55-65% carbohydrate and 20- 50% protein. Due to the symbiotic association with rhizobium bacteria it enables the natural fixation of atmospheric nitrogen. It can also be used as a cover crop before or after cereal crops in rotation, which provides a good green manure. Green gram was sown in black soil with the help of Happy seeder as shown in Plate 3.38 (a) and closed view of green gram in fluted roller is shown in Plate 3.38 (b).

(a) **(b)**

(a) Sowing of black gram; (b) Closed view of black gram in fluted roller

Plate 3.38 Sowing of Green gram in black soil by Happy Seeder

3. Maize

Maize (*Zea Mays* L.) is the world's leading crop and is widely cultivated as cereal grain whichbelongs to the family Poaceae. Globally, maize is known as queen of cereals because of its highest genetic yield potential. Maize is the only food cereal crop that can be grown in diverse seasons, ecologies. In Rabi season, crop is sown in the month of November end corresponding with the oneset of monsoon.(*Anonymous*, 2015).Spring crops are sown during late February to end of march. The crop period is 90-100 days. Maize was sown in sandy soil with the help of Happy seeder as shown in Plate 3.39 (a) and closed view of maize in fluted roller is shown in Plate 3.39 (b).

(a) (b)

(a) Sowing of black gram; (b) Closed view of black gram in fluted roller

Plate 3.39 Sowing of Maize by Happy Seeder in Sandy soil

3.11 Machine parameters

The crop and machine parameter plays a significant role. The crop parameters considered for the sowing of black gram, Green gram and Maize using happy seeder were as follows;

1. Operating speed

At 1500 engine rpm in L-2 gear, the operating speeds of Happy Seeder were measured in three different type of soil by taking stopwatch. The operating speeds in three different soils were taken.

2. Row to row spacing

Generally, the spacing between the two consecutive furrow openers gives the row to row spacing of Zero-Till Happy Seeder which is 22.5cm (9 inches). It is measured using ruler as shown in Plate 3.40

Plate 3.40 Row to row spacing

3. Depth of Operation

The depth of operation of Zero-Till Happy Seeder in three different soils namely sandy, black and clay loam was measured by using a ruler keeping it in the furrow depth obtained by the operation of inverted tyne type furrow openers of Happy Seeder. The average depth of operation for all soils was measured as shown in Plate3.45

Plate 3.45 Depth of operation

4. Furrow width

Furrow width is the width of furrow openers formed by Zero-Till Happy Seeder. It was maintained constant for all three different types of soil. Furrow width was measured by using a ruler as shown in Plate 3.46

Plate3.46 Furrow width

1. Crop Parameters

i. Germination holes

The germination holes was calculated for three different kind of seeds i.e. Black gram, Green gram and Maize. Seeds dropped in the furrows by Happy Seeder were calculated at six different locations and average was taken. It was 5-6 for black gram and green gram and 2-3 for maize.

ii. Plant to plant spacing

The plant to plant spacing was measured by taking steel rule keeping it between one plant to the next plant in a row. It was different for three crops.

iii. Plant height

Plant height is an important quantitative attribute which determines plant growth. It is recorded by holding the ruler close to the stem of the crop. The height was measured from the ground level where the roots start to grow, to the leaf base of the highest fully expanded leaf. Plant height of three different crops Black gram, Green gram and Maize was recorded from six different locations in both Happy Seeder sown plot and traditional sown plot

4.1. Black gram

The measurement of plant height after seven days of sowing (7 DAS) of Black gram in Happy seeder and traditional sown field is given in Plate 3.42(a) and (b).

(a) Plant height of Black gram in Happy Seeder sown plot

(b) Plant height of Black gram in traditional sown plot

Plate 3.42 Plant height of Black gram in Happy Seeder and traditional sown plot

4.2. Green gram

The measurement of plant height of green gram in Happy seeder and traditional sown field is given in Plate 3.43 (a) and (b).

(a) Plant height of Green gram in Happy Seeder sown plot

(b) Plant height of Green gram in traditional sown plot

Plate 3.43 Plant height of Green gram in Happy Seeder and traditional sown plot

4.3. Maize

The measurement of plant height of maize in Happy seeder and traditional sown field is given in Plate 3.44 (a) and (b).

(a) Plant height of Maize in Happy Seeder sown plot

(b) Plant height of Maize in traditional sown plot

Plate 3.44 Plant height of Maize in Happy Seeder and traditional sown plot

3.10 Procedure for Germination test in Field condition

Germination test in field was done by sowing seeds in a plot of one meter square area ($1m^2$) with a standard row spacing as in case of Happy Seeder i.e. 9 inches. The number of seedlings per meter row length in 5 adjacent rows was recorded in each plot and their average value was calculated, and then converted to number of plants per square meter area. The same procedure is repeated for all three replications.

3.10.10 Tools and devices

1. Measuring Tape
2. Steel rule
3. Seeds
4. Stopwatch
5. Marking Pegs

3.10.11 Procedure

1. Small plot of field with $1m^2$ area was measured with the help of measuring tape and pegs were placed at four corners of the square plot.
2. The same procedure was repeated at three different sites selected as replications.
3. Then, seeds of black gram, green gram and Maize were sown in three different plots with the help of Zero-Till Happy Seeder.
4. The number of seedlings per meter row length in 5 adjacent rows was recorded in each plot.
5. The average value obtained in the three different replicated plots was calculated.
6. The number of plants emerged to the number of seeds sown per meter row length in one meter square area gave the germination percentage in field conditions.

3.10.12 Calculation of Germination Rate

Germination rate is the average number of plants emerged per meter row length in $1m^2$ plot to the total number of seeds per meter row length. The germination percentage was calculated by the given formula in the equation 3.9.

$$\text{Germination percentage} = \frac{\text{Number of plants germinated per unit area}}{\text{Total number of seeds per unit area}} \times 100 \quad ..(3.9)$$

CHAPTER IV

RESULTS AND DISCUSSIONS

This chapter contains the results and discussions of the experiments conducted in order to fulfill the objectives of the study. The Zero-Till Happy Seeder was tested under different soil conditions taking three crops as reference namely black gram, green gram and maize. The development and fabrication of furrow closers attached to the Happy Seeder was carried out at Dr. M.V Rao workshop of Dr. NTR College of Agricultural Engineering, Bapatla. The cost economics was estimated and savings in terms of time and energy was compared with the traditional methods.

4.1 TESTING OF HAPPY SEEDER UNDER LABORATORY CONDITIONS

Prior to sowing operation in field plots it is necessary to calibrate the Zero-Till Happy Seeder. The calibration of Happy Seeder was done to find the seed and fertilizer rate. The lab tests with Happy Seeder for seed and fertilizer rate of Black gram, Green gram and Maize with three replications conducted as explained in the section 3.13 gained the results obtained were mentioned below;

The test results of seed and fertilizer metering rate of black gram, green gram and maize were given in Table 4.1

Table.4.1 Calibration data of Happy Seeder

Type of Seed	Metering Rate	
	Average Seed(kg ha^{-1})	Average Fertilizer DAP(kg ha^{-1})
Black gram	31.2	45.0
Green gram	22.25	44.5
Maize	26.65	60.0

The seed rate of black gram, green gram and maize at full hopper discharge was 31.2, 22.25 and 26.65 kg ha^{-1} respectively. The fertilizer used was Diammonium Phosphate (DAP).

4.2 PHYSICAL PROPERTIES

4.2.1 Moisture Content

1. Seed Samples

Moisture content of green gram, black gram and maize seeds were measured in the laboratory in Bio hall hot air oven and the values are noted in the Table 4.2.

Table 4.2 Moisture content of seed samples

Replications	Moisture Content (% dry basis)		
	Black gram	**Green gram**	**Maize**
1	11.5	9.5	15
2	11	10	15.2
3	11.5	9.8	15.1
Mean± S.D	11.3±0.2	9.66 ±0.25	15.1±0.1

The average moisture content of black gram was 11.33% at the time of sowing and the average moisture content of green gram was 9.66 % and that of maize was 15.1%. At these values of moisture content, better crop yields were obtained.

2. Soil samples

Moisture Content at the time of sowing in different samples such as black, clay loam soil and sandy was measured and the readings obtained are given in the Table 4.3.

Table 4.3 Moisture content of soil

Replications	Moisture Content (% dry basis)		
	Clay loam	**Sandy**	**Black**
1	24.2	22	23.5
2	24.5	22.3	23.3
3	24.8	22.9	23.8
Mean± S.D	24.5± 0.3	22.4± 0.4	23.5±0.2

The average moisture content of clay loam soil was 24.5% at the time of sowing and that of sandy soil was 22.4% and black soil was 23.53%.

3. Paddy straw

Moisture content of collected paddy straw samples after the harvesting of paddy field was measured and the readings obtained are given in the Table 4.4.

Table 4.4 Moisture content of paddy straw

Collected Paddy straw sample	Moisture Content (% dry basis)
Sample 1	4.8
Sample 2	5.0
Sample 3	4.9
Mean ± S.D	4.9 ± 0.1

The average moisture content of collected paddy straw samples from three different locations of field was found to be 4.9%.

4.2.2 Bulk Density

The bulk density of three types of soils namely sandy, clay loam and sandy soil were measured as explained in the section 3.7 and the results obtained are given in Table 4.5

Table 4.5 Bulk density of soils

Replications	Bulk density (g/cc)		
	Clay loam	**Sandy**	**Black**
1	1.45	1.74	1.52
2	1.48	1.76	1.48
3	1.51	1.75	1.47
Mean ± S.D	1.48±0.03	1.75±0.01	1.49±0.04

The bulk density of clay loam, sandy and black soil was found to be 1.48, 1.75 and 1.49 g cm^{-3} respectively. It was found that the bulk density of sandy soil was more with a value of 1.75 g cm^{-3} compared to other soils because the porosity or total pore volume is less in sandy soil than clayey soils. This characteristic causes the bulk density to be higher for sandy soil.

4.3 SEED GERMINATION TEST UNDER LABORATORY CONDITIONS

The germination values of selected seed samples of Green gram, Black gram and Maize are shown in Plate 4.1

(a)

(b)

(c)

(a) Green gram ; (b) Black gram ; (c)Maize

Plate 4.1 Germinated seed samples under laboratory conditions

The germination values of Green gram, Black gram and Maize seed in percentage mentioned in Table 4.6.

Table 4.6 Germination Percentage under Lab Conditions

Replications	Germination (%)		
	Green gram	**Black gram**	**Maize**
1.	85	88	80
2.	84	86	83
3.	83	84	82
Mean± S.D	84±1	86±2	81.6±1.5

From the above table, it was found that the germination percentage of black gram was 86% and that of green gram was 84% followed by maize with a value of 81.6%.

4.4 EVALUATION OF TRACTOR OPERATED ZERO-TILL HAPPY SEEDER UNDER DIFFERENT SOIL CONDITIONS

The Happy Seeder was tested in different soils as per the conformity of Indian standards requirement as per IS: 6813:2000 under different soil conditions. The field performance parameters such as fuel consumption, draft, and depth of operation, theoretical and actual field capacity, field efficiency, ground wheel slippage, operating speed, average power requirement and speed index were calculated from the data collected.

4.4.1 Actual Working width

The actual working width of the Happy Seeder was obtained by multiplying the distance between two consecutive furrow openers with number of furrow openers which was found to be 2.25m.

4.4.2 Ground Wheel Slip

The ground wheel slip of Happy Seeder in three different soils was measured as explained in the section 3.9.2 obtained the results as mentioned in Table 4.7.

Table 4.7 Ground wheel slip of Happy Seeder in three different soils

S.No.	Type of soil	Ground wheel slip(%)
1.	Sandy	6.5
2.	Black	3.5
3.	Clay loam	2.5

It was found that ground wheel slip of Happy Seeder was more 6.5% in sandy soil because of no traction produced in the lugs of ground wheel causing more slip, whereas in clay loam it was less due to more traction provided to the lugs due its compact soil structure.

4.4.3 Draft Force

The average draft force of Zero-Till Happy Seeder was measured by adopting the standard procedure as explained in section 3.8.3.The draft force of Zero-Till Happy Seeder in different types of soil is given in Table 4.8.

Table 4.8 Draft force of Zero-Till Happy Seeder

Type of soil	Depth(cm)	Draft Force (kN)
Clay Loam	5.3	4.6
	5.5	5.0
	5.8	5.5
	6.1	5.8
	6.3	6.2
Average	**5.8**	**5.42**
Sandy	5.8	3.9
	6.1	4.3
	6.2	4.7
	6.4	5.1
	6.7	5.4
Average	**6.24**	**4.68**
Black	4.8	6.0
	4.9	6.3
	5	6.7
	5.1	7.0
	5.4	7.2
Average	**5.04**	**6.64**

4.4.2.1 Effect of depth of operation on draft of Zero-Till Happy Seeder in different type of soil.

The effect of depth of operation on draft of Zero-Till Happy Seeder in clay loam soil is shown in Fig 4.1.

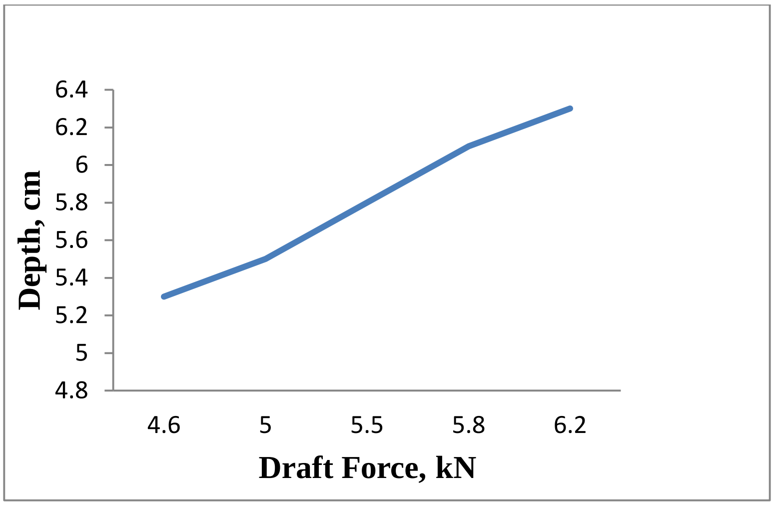


Fig.4.1 Effect of depth of operation of implement on draft in clay loam soil

From the graph, it can be observed that when the depth of operation in clay loam soil changes from 5.3 cm to 6.3 cm, the draft force varied from 4.6 kN to 6.2 kN at load condition and 2kN at no load condition. This is due to more acceleration of soil particles. The average draft force requirement in clay loam soil was in between sandy and black soil.

4.4.2.2 Effect of Depth of Operation on Draft of Zero-Till Happy Seeder in Sandy soil.

The effect of depth of operation on draft of Zero-Till Happy Seeder in Sandy soil is shown in Fig 4.2.

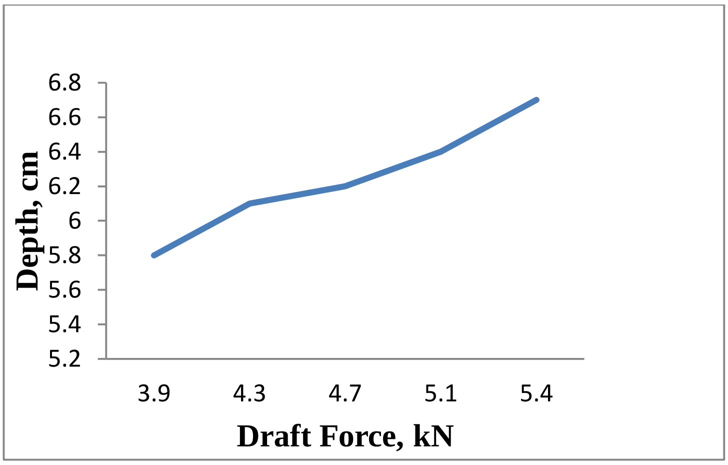


Fig.4.2 Effect of depth of operation of implement on draft force in Sandy soil

From the graph, it can be observed that when the depth of operation in sandy soil changes from 5.8 cm to 6.7cm,the draft force varied from 3.9 kN to 5.4 kN at load condition and 1.85kN at no load condition. The average draft force requirement was less in sandy soil compared to clay loam and black soil because of more acceleration of soil particles.

4.2.2.3 Effect of Depth of Operation on Draft of Zero-Till Happy Seeder in black soil

The effect of depth of operation on draft of Zero-Till Happy Seeder in black soil is shown in Fig 4.3.

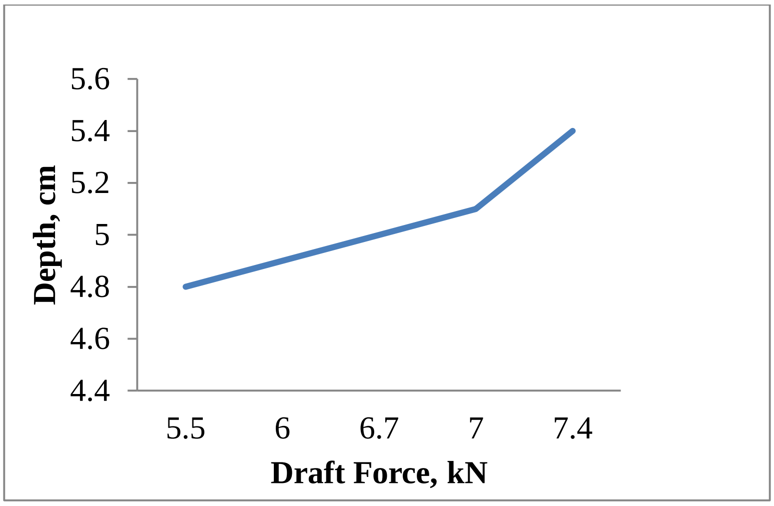


Fig 4.3 Effect of depth operation of implement on draft in black soil

From the graph, it can be observed that when the depth of operation in black soil changes from 4.8cm to 5.4cm, the draft force varied from 6.0kN to 7.2kN at load condition and 1.98 kN at no load condition. The average draft force requirement was more in black soil compared to clay loam and sandy because of less acceleration of soil particles.

4.4.3 Fuel Consumption

Fuel Consumption was found more in Black soil compared to clay loam and sandy soil because of soil moisture, wheel slippage occurred resulting in more time to cover the unit area consuming more fuel compared to the other soils. The fuel consumption results are given in Table 4.9.

Table 4.9 Fuel consumption in different Soils

Type of Soil	Fuel Consumption(l ha^{-1})
Sandy	4.05
Black	4.22
Clay loam	4.17

4.4.4 Operating Speed

At 1500 engine rpm in L-2 gear, the operating speeds of Happy Seeder were measured in three different type of soils by noting time taken in stopwatch. The operating speeds in three different soils are given in Table 4.10.

Table 4.10 Operating Speeds of Happy Seeder in different soils

Type of soil	Operating Speed, km h^{-1}
Black	1.5
Sandy	1.6
Clay loam	1.47

It was observed that operating speed of Happy Seeder was more in Sandy soil i.e. 1.6 km h^{-1} followed by 1.5 km h^{-1} in sandy loam and 1.47 km h^{-1} in clay loam soil.

4.4.5 Field Capacity

Theoretical and actual field capacity in three different soils namely sandy, sandy loam and clay loam was measured and field efficiency was calculated as a ratio of actual to theoretical field capacity and the values obtained are presented in the Table 4.11.

Table 4.11 Theoretical and actual field capacity

Type of Soil	Theoretical Field Capacity (ha h^{-1})	Actual Field Capacity(ha h^{-1})	Field Efficiency(%)
Sandy	0.547	0.345	63.07
Black	0.597	0.361	60.46
Clay loam	0.500	0.310	62

It was found from the data that for sandy soil, theoretical field capacity was more and actual field capacity was less resulting in high field efficiency i.e. 63.07%.

Similarly, for black soil, the field efficiency was 60.46% and for clay loam soil and for clay loam soil, it was 62 %.Hence, it was concluded that sandy soil resulted in high field efficiency compared to clay loam and black soil.

4.4.6 Power Requirement of Happy Seeder

The power requirement of tractor operated Zero-Till Happy Seeder in three different soils namely sandy, sandy loam and clay loam was measured as explained in section 3.9.10 an the result obtained given in the Table 4.12.

Table 4.12 Power requirement of Happy Seeder in three different soils

S.No	Type of soil	Drawbar Horsepower (hp)
1.	Sandy	10.18
2.	Clay loam	11.05
3.	Black	13.27

The power requirement of Happy Seeder in sandy soil was less i.e. 10.18 hp due to less draft required to operate followed by 11.05 hp in clay loam whereas it was more i.e.13.27 hp in black soil due to more draft requirement.

4.4.7 Wheel Slip of Tractor

The wheel slip of tractor attached to Happy Seeder in three different soils was measured as explained in the section 3.9.11 and the results as mentioned in Table 4.13.

Table 4.13 Wheel slip of tractor in three different soils

S.No.	Type of soil	Wheel slip(%)
1.	Sandy	2
2.	Clay loam	3.5
3.	Black	4

It was found that wheel slip of tractor was more i.e. 4% in black soil because of more moisture in the soil causing more wheel slip whereas in sandy it was less i.e. 2% due to less moisture enabling the wheel to cause lower slip.

4.4.8 Speed Index

Speed Index of Zero-Till Happy Seeder was measured by using tachometer for rotor speed and forward speed of travel in three different types of soils as explained in the section 3.8.4. The performance of Straw Management rotor for cutting paddy straw residues mainly depends on speed index. Speed index associated with different combinations of engine speed, rotor speed and forward gears as shown in Table 4.14.

Table 4.14 Speed index associated with different combinations of engine speed, rotor speed and forward speed

Type of Soil	Engine Speed (rpm)	Forward Speed (km h^{-1})	Rotor Speed (km h^{-1})	Speed Index
Clay loam	1500	1.5	15.42	0.09
	1700	2.45	14.21	0.17
	1900	2.60	13.20	0.19
Sandy	1500	1.6	17.98	0.08
	1700	2.93	15.11	0.19
	1900	3.7	14.77	0.25
Black	1500	1.47	14.44	0.10
	1700	2.22	13.22	0.16
	1900	2.49	13.99	0.17

It was found that in clay loam when the engine speed increased from 1500 rpm to 1900 rpm, forward speed increased from 1.5 km h^{-1} to 2.6 km h^{-1} and the rotor speed decreased from 15.42 to 13.20 as a result of which speed index increased from 0.09 to 0.19. Similarly, in sandy when the engine speed increased from 1500 rpm to 1900 rpm, forward speed increased from 1.6 km h^{-1} to 3.7 km h^{-1} and the rotor speed decreased from 17.98 to 14.77 as a result of which speed index increased from 0.08 to 0.25.

Similarly, in black soil when the engine speed increased from 1500 rpm to 1900 rpm, forward speed increased from 1.47 km h^{-1} to 2.49 km h^{-1} and the rotor speed decreased from 14.44 to 13.99 as a result of which speed index decreased from 0.10 to 0.17 Speed index increased with increase in rotor speed in all three soils. The rotor speed index was found maximum i.e.0.25 in sandy soil followed by clay loam (0.19) and black soil (0.17) which resulted in better operation of flail blades in cutting the paddy residues in the field. Speed Index was found more in sandy soil as rotor speed was more followed by clay loam and black soil.

4.5 MACHINE AND CROP PARAMETERS FOUND IN THREE DIFFERENT SOILS DURING EVALUATION

The crop parameters of black gram, green gram and maize sown in three different soils were measured and the results obtained are presented in Table 4.15

Table 4.15 Machine and Crop parameters found in three different soils

Parameters	Type of Soil		
	Sandy	**Clay loam**	**Black**
Type of Crop	Maize	Green gram	Black gram
Machine Parameters			
Operating speed, km h^{-1}	1.6	1.47	1.5
Seed rate, kg ha^{-1}	26.65	22.5	31.2
Row spacing, cm	22.5	22.5	22.5
Furrow Width, cm	4	4	4
Depth of operation, cm	6.24	5.8	5.04
Crop Parameters			
Germination holes	2	5-6	5-6
Plant to plant spacing, cm	3	0.5	1.0

It was found that the row spacing was maintained constant in all three crops i.e. 22.5 cm by Zero-Till Happy seeder. The germination holes was 2 in case of maize, 5-6 in case of black gram and green gram and the hill to hill spacing varied in case of maize i.e. 30 cm and 24.5 cm in black gram and green gram. Furrow width was maintained constant with 4cm in all the three cases. Operating speeds varied in all three types of soil with high speed in clay loam because of clod formation and moisture holding capacity and low in sandy soil because of less clod formation and low moisture holding capacity. The average depth of operation was more i.e. 6.24 cm in case of sandy soil was more because of its loose soil particles enabling the implement to penetrate deep into the soil whereas in clay loam it was less (5.04cm) due to it's compaction of soil particles held tightly.

4.6 SUMMARY OF FIELD PERFORMANCE RESULTS IN BLACK SOIL

The summary of field performance results of black soil are given in Table 4.16.

Table 4.16 Summary of field performance results of Black soil

PARAMETERS	RANGE
Type of soil	Black
Soil moisture (%)	24.5
Type of crop	Green gram
Operating speed (km h^{-1})	1.47
Wheel slip (%)	4.0
Ground wheel slip (%)	3.5
Average depth of operation (cm)	5.04
Row to row spacing (cm)	22.5
Average seed spacing (cm)	0.5-1
Field efficiency (%)	60.46
Average draft (kN)	6.64
Fuel consumption (l h^{-1})	4.22

4.6.1 Rate of work

1. The average area covered was recorded as 0.29 ha at average operating speed 1.47 km h^{-1}.
2. The theoretical and actual field capacity were recorded as 0.597 and 0.361.

3. The field efficiency of happy seeder was recorded as 60.46 %.

4.6.2 Quality of work

1. The average depth of sowing green gram by happy seeder was recorded as 6-7cm.
2. The average depth of placing the fertilizer was recorded as 7-7.5cm.
3. The average number of seeds per meter row length was recorded as 54-55.
4. The average spacing between seeds was recorded as 0.5-1cm.
5. The deviation of seed from the center line was observed as 4.1 to 4.6mm.

4.7 SUMMARY OF FIELD PERFORMANCE RESULTS IN CLAY LOAM SOIL

The summary of field performance results of clay loam soil are given in Table 4.17.

Table 4.17 Summary of field performance results of Clay loam soil

PARAMETERS	RANGE
Type of soil	Clay loam
Soil moisture (%)	23.5
Type of crop	Black gram
Operating speed (km h^{-1})	1.5
Wheel slip (%)	3.5
Ground wheel slip (%)	2.5
Average depth of operation (cm)	5.8
Row to row spacing (cm)	22.5
Average seed spacing (cm)	0.5-1
Field efficiency (%)	62
Average draft (kN)	5.42
Fuel consumption (l h-1)	4.17

4.7.1 Rate of work

1. The average area covered was recorded as 0.29 ha at average operating speed 1.5 km h^{-1}.
2. The theoretical and actual field capacity were recorded as 0.5 and 0.310.
3. The field efficiency of happy seeder was recorded as 62%.

4.7.2 Quality of work

1. The average depth of sowing maize by happy seeder was recorded as 6-7cm.
2. The average depth of placing the fertilizer was recorded as 7-7.5cm.
3. The average number of seeds per meter row length was recorded as 50-55.
4. The average spacing between seeds was recorded as 0.5-1cm.
5. The deviation of seed from the centre line was observed as 5.1 to 5.6mm.

4.8 SUMMARY OF FIELD PERFORMANCE RESULTS IN SANDY SOIL

The summary of field performance results of sandy soil are given in Table 4.18
.

Table 4.18 Summary of field performance results of sandy soil

PARAMETERS	RANGE
Type of soil	Sandy
Soil moisture (%)	22.5
Type of crop	Maize
Operating speed (km h^{-1})	1.6
Wheel slip (%)	3.5
Ground wheel slip (%)	6.5
Average depth of operation (cm)	6.24
Row to row spacing (cm)	22.5
Average seed spacing (cm)	0.5-1
Field efficiency (%)	63.07
Average draft (kN)	4.68
Fuel consumption (l h^{-1})	4.05

4.8.1 Rate of work

1. The average area covered was recorded as 0.29 ha at average operating speed 1.6 km h^{-1}.
2. The theoretical and actual field capacity were recorded as 0.547 and 0.345.
3. The field efficiency of happy seeder was recorded as 63.07%.

4.8.2 Quality of work

6. The average depth of sowing maize by happy seeder was recorded as 6-6.5cm.
7. The average depth of placing the fertilizer was recorded as 7-7.5cm.

8. The average number of seeds per meter row length was recorded as 24-25.
9. The average spacing between seeds was recorded as 0.5-1cm.
10. The deviation of seed from the centre line was observed as 5.1 to 5.6mm.

4.9 TRIALS FOR OPTIMUM SPEED OF HAPPY SEEDER

The performance evaluation of happy seeder at different operating speeds in three different types of soil was carried out to know the best operating speed.

1. **Clay loam soil**

The Happy Seeder was evaluated in sandy loam soil with black gram as reference crop on the basis of theoretical field capacity, actual field capacity, field efficiency, fuel consumption, ground wheel slippage at three different operating speeds mainly 2.5, 3.0 and 3.5 km h^{-1}. The area covered was 0.29 ha and replicated results is given in Table 4.19.

Table 4.19 Field performance data of Happy Seeder in clay loam soil

Speed (km h^{-1})	Trials	TFC (ha h^{-1})	AFC (ha h^{-1})	Efficiency (%)	Fuel consumption (L h^{-1})	Ground Wheel slip (%)
2.5	T1	0.576	0.334	57	4.05	5.5
	T2	0.532	0.310	58	4.09	5.4
	T3	0.446	0.386	56	4.12	5.5
3.0	T1	0.500	0.310	62	4.17	5.9
	T2	0.597	0.361	60.46	4.22	6.0
	T3	0.547	0.345	63.07	4.30	6.0
3.5	T1	0.496	0.256	51.61	4.36	7.1
	T2	0.447	0.241	53.91	4.40	7.29
	T3	0.456	0.231	50.65	4.44	7.1

The operating speed of Happy Seeder could be varied from 2.5 to 3.5 kmh^{-1} .Field efficiency was maximum i.e. 60% at a speed of 3 km h^{-1} with minimum fuel consumption of 4.17 l h^{-1} and ground wheel slip of 5.9%. Hence, the optimum speed of 3 km h^{-1} may be used.

2. Black soil

The Happy Seeder was evaluated in black soil for green gram crop on the basis of theoretical field capacity, actual field capacity, field efficiency, fuel consumption, ground wheel slippage at three different operating speeds i.e. 2.5, 3.0 and 3.5 km h^{-1}. The area covered was 0.29 ha and the replicated results is given in Table 4.20.

Table 4.20 Field performance data of Happy Seeder in Black soil

Speed (km h^{-1})	Trials	TFC (ha h^{-1})	AFC (ha h^{-1})	Efficiency (%)	Fuel consumption(l h^{-1})	Ground Wheel slip (%)
2.5	T1	0.576	0.334	57.9	4.05	6.2
	T2	0.532	0.310	58.2	4.09	6.3
	T3	0.549	0.322	58.6	4.12	6.3
3.0	T1	0.500	0.310	60.33	4.20	6.8
	T2	0.597	0.361	60.46	4.22	6.84
	T3	0.547	0.345	60.00	4.22	6.5
3.5	T1	0.496	0.256	52.61	4.36	6.7
	T2	0.447	0.241	54.91	4.40	7.02
	T3	0.456	0.231	50.65	4.44	7.04

It was found that when the operating speed of Happy Seeder varied from 2.5 to 3.5 km h^{-1}. Field efficiency was maximum i.e. 60% at a speed of 3 kmh^{-1}. Hence, the optimum speed of 3 km h^{-1} may be used.

3. Sandy Soil

The Happy Seeder was evaluated in sandy loam soil on the basis of theoretical field capacity, actual field capacity, field efficiency, fuel consumption, ground wheel slippage at three different operating speeds mainly 2.5, 3.0 and 3.5 km h^{-1}. The area covered was 0.29 ha. The crop taken was maize. The experiment was replicated thrice for best results given in Table 4.21.

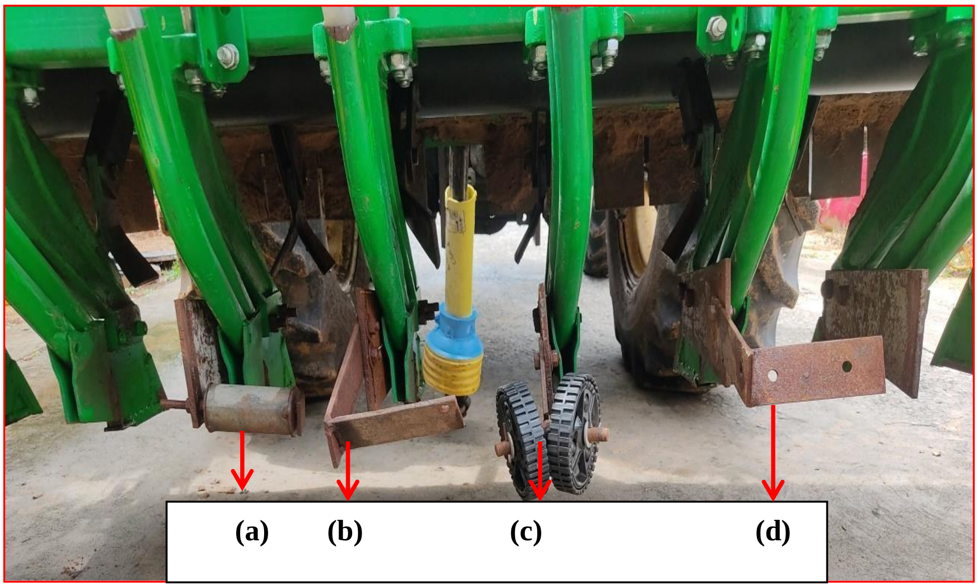
Table 4.21 Field performance data of Happy Seeder in Sandy soil

Speed (km h^{-1})	Trials	TFC (ha h^{-1})	AFC (ha h^{-1})	Efficiency (%)	Fuel consumption (L h^{-1})	Ground Wheel slip (%)
2.5	T1	0.576	0.334	57	4.05	5.81
	T2	0.532	0.310	58	4.09	5.6
	T3	0.446	0.386	56	4.12	5.6
3.0	T1	0.560	0.350	62.5	4.15	5.5
	T2	0.558	0.352	63.08	4.17	5.4
	T3	0.547	0.345	63.07	4.22	5.5
3.5	T1	0.496	0.256	51.61	4.36	6.2
	T2	0.447	0.241	53.91	4.40	6.2
	T3	0.456	0.231	50.65	4.44	6.3

It was found that when the operating speed of Happy Seeder varied from 2.5 to 3.5 km h^{-1}.Field efficiency was maximum i.e. 63% at a speed of 3 km h^{-1} and it was selected as the best operating speed of Happy Seeder in sandy soil.

4.10 PERFORMANCE OF FURROW CLOSERS ATTACHED TO ZERO-TILL HAPPY SEEDER

The developed furrow closers of L-Type blade at 30 and 120 degree inclination, roller type and double wheel type were attached to the furrow openers of Zero-Till Happy Seeder. The different types of furrow closers attached to Happy Seeder are given in Plate.4.2



a.Roller ; b.L-120 blade; c. Double wheel ; d. L-30 Blade

Plate 4.2 Different Furrow closers attached to Happy Seeder

4.10.1 Effect of Operating Speed on Depth of Furrow Coverage of Furrow Closers

The effect of operating speed on depth of furrow coverage of furrow closers was evaluated at four different operating speeds i.e. 2, 2.5,3 and 3.5 km h^{-1} to find the depth of coverage.. The effect of operating speed on depth of furrow coverage of furrow closersis given in Fig.4.4.

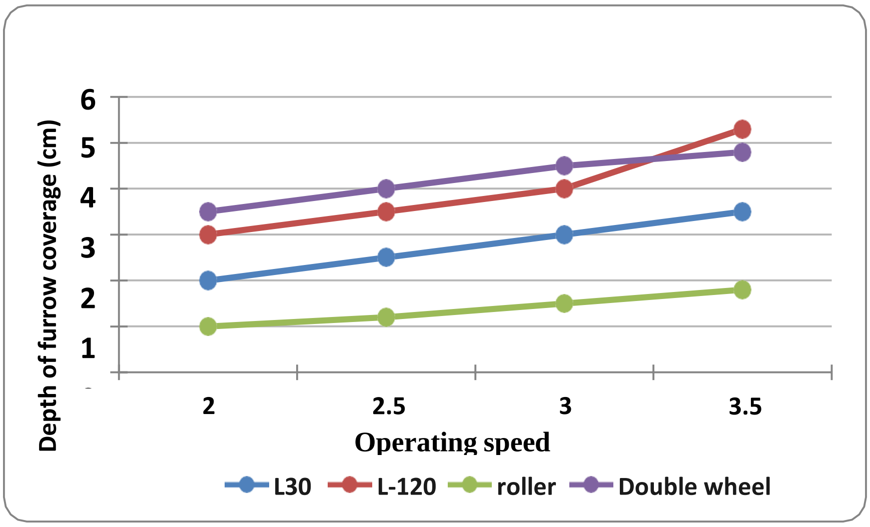


Fig 4.4 Depth of furrow coverage of different furrow closers at different operating speeds.

4.10.1.1 ANOVA

The STATA software was used for data analysis. ANOVA test was applied to the depict the variations in depth of coverage of different types of furrow closers namely L-Type blade at 30° inclination, L-Type blade at 120° inclination, Roller and double wheel type at different operating speeds (2, 2.5 and 3 km h^{-1}).The design used was Completely randomized block. Effect of operating speed on depth of operation was evaluated by applying Regression test to different types of furrow closers. P-value was calculated to test the significance which should be less than 0.05 ($p<0.05$) indicates that there is a significant difference at 5% level. In regression test, the R^2 coefficient of determination is a statistical measure of how well the regression predictions approximate the real data points An $R^2=1$ indicates that the regression predictions perfectly fit the data. Dependent variable was taken as depth of furrow coverage of furrow closers and independent variables as operating speed .The depth of furrow coverage of four different furrow closers at four different operating speeds for four replications is given in Table 4.22

Table 4.22 Depth of coverage of four different furrow closers at different operating speeds

Replications at different operating speeds	Depth of coverage, cm of different types of Furrow Closers			
R1	**L-30 Blade**	**L-120 Blade**	**Roller**	**Double Wheel**
2	2	4	1	3.5
2.5	2.5	3.5	1.2	4
3	3	4	1.5	4.5
3.5	3.5	5.3	1.8	4.8
R2				
2	2.2	4.1	1.2	3.4
2.5	2.4	3.6	1.3	3.8
3	2.9	3.9	1.5	4.6
3.5	3.6	5.2	1.7	4.7
R3				
2	2.1	3.9	1.1	3.5
2.5	2.6	3.4	1.1	3.9
3	3.1	4.1	1.6	4.5
3.5	3.4	5.2	1.7	4.8
R4				
2	1.9	4	1.2	3.6
2.5	2.4	3.5	1.1	3.9
3	3.8	4.2	1.4	4.4
3.5	3.3	5.1	1.6	4.9

4.10.1.2 ANOVA AND REGRESSION TEST APPLIED TO FURROW CLOSERS

The ANOVA and Regression test was applied to test the significance of different furrow closer at four different operating speeds i.e. 2, 2.5 3, 3.5 kmh^{-1}.The value of P>|t| =0.004 which isless than 0.05 denotes that there is significant difference. R^2 is a measure of the goodness of fit of model. An R^2=1 which is near to 1 indicates that the regression predictions fit the data.

4.10.1.3 Univariate Analysis of Variance applied to four different furrow closers.

4.10.1.3.1 L type blade at 30° inclination

From the statistical analysis given in Appendix-c, it can be concluded as L type blade at 30° inclination showed non significance among the treatments with p value 0.1which is greater than 0.05. This means that L-30 blade is not suitable for efficient covering of furrow closers with regression coefficient R Squared = .889 (Adjusted R Squared = .861)

4.10.1.3.2 L type blade at 120° inclination

From the statistical analysis given in Appendix-C, it can be concluded as L type blade at 120° inclination showed significance results among the treatments with p value less than 0.05. This means that L-120 blade is suitable for efficient closing of furrow closers.

4.10.1.3.3 Roller type furrow closer

From the statistical analysis given in Appendix-c, it can be concluded as roller type furrow closer showed non-significant results among the treatments with p value 0.80 greater than 0.05. This means that roller type furrow closer is not suitable for efficient closing of furrow closers with regression coefficient of 0.904 (Adjusted R Squared = .880)

4.10.1.3.4 Double wheel type furrow closer

From the statistical analysis given in Appendix-C, it can be concluded as double wheel type furrow closer showed significant results among the treatments with p value less than 0.01 indicates significance at 1% level. This indicates that double type furrow closer is suitable for efficient closing of furrow closers.

4.11 SEED GERMINATION IN FIELD CONDITION

The germination of black gram, green gram and maize under field conditions after 7 days of sowing are shown in Plate 4.3

(a) Germination of Black gram in sandy loam soil

The germination of Green gram in clay loam soil after 7 days of sowing is given in Plate 4.3(b)

(b) Germination of Green gram in clay loam soil

The germination of maize in sandy soil after 7 days of sowing is given in Plate 43(c)

(c) Germination of Maize in Sandy soil

Plate 4.3 Germination of seeds under field conditions

The germination percentage of green gram, black gram and maize are given in the Table 4.23

Table 4.23 Germination results under field conditions

	Germination Percentage (%)		
Replications	**Green gram**	**Black gram**	**Maize**
1.	85	88	80
2.	84	86	83
3.	83	84	82
Mean±S.D	84.12± 1	85±2	82±1.5

The germination percentage of Green gram was found to be 84.1% Black gram 85% and that of maize was 82%.

4.12 EFFECT OF MOISTURE CONTENT OF SOIL ON DAYS AFTER SOWING (DAS)

Moisture content of sandy, clay loam and sandy soil over days after sowing of black gram, green gram and maize with Happy Seeder and traditional method was collected and graphically represented.

4.12.1 Effect of Moisture Content of Black Soil on Days After Sowing (DAS) of Green Gram

Moisture content of black soil varied with the days after sowing of Black gram, Green gram and Maize on date of sowing, it was 26% in Happy Seeder sown field and 27% in traditional sown field. After 20 DAS, the moisture content decreased in both methods and increased on irrigation of crop and decreased at the time of harvesting. It was found that it takes more time in Happy Seeder sown field conserve moisture to some extent. The effect of moisture content of black soil on days after sowing (DAS) of green gram is given in Fig 4.5.

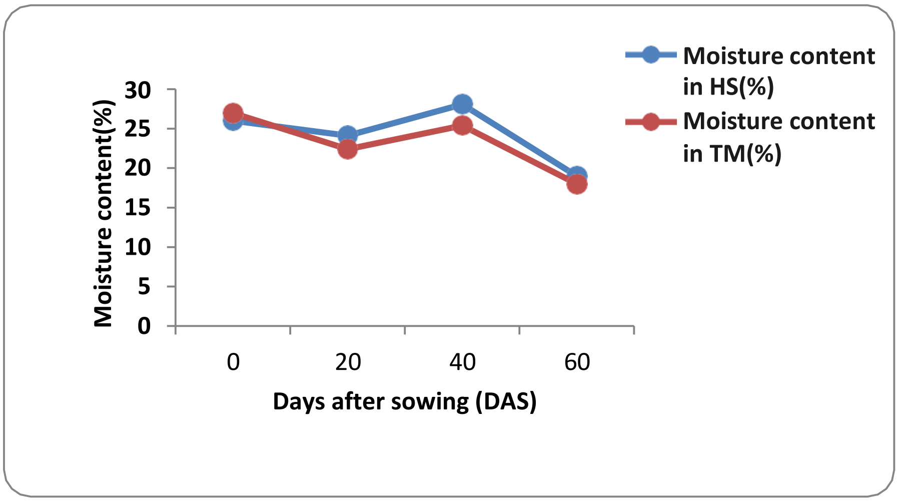


Fig.4.5 Effect of moisture content of black soil on days after sowing (DAS) of green gram

It was found that the moisture content at the time of sowing in clay loam soil was more i.e 25.4% in TM (traditional method) compared to 25% in HS (Happy Seeder) technology sown plot because it took time for straw retention to conserve moisture due to straw residues. After 20 days of sowing, moisture content dropped in both the fields .Then after 40 days of sowing, moisture content reached to a peak value of 28% in HS because of irrigation. After irrigation, the moisture content of soil attained to a maximum value of 29.2% in both methods and then dropped to 15.5%at the time of harvest.

4.12.2 Effect of Moisture Content of Clay Loam Soil on Days after Sowing (DAS) of Black Gram

The effect of moisture content of sandy loam soil over days after sowing (DAS) of black gram is shown in Fig 4.6.

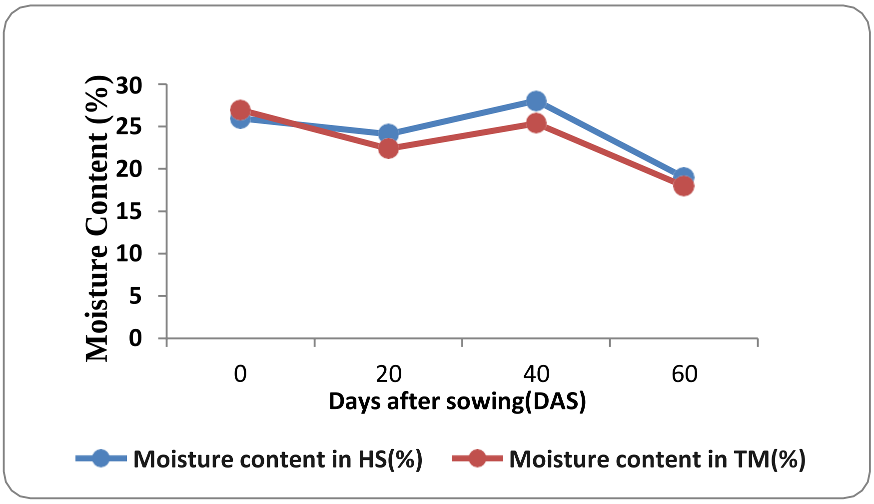


Fig.4.6 Effect of moisture content of clay loam soil on days after sowing (DAS) of black gram

It was found that the moisture content of clay loam soil at the time of sowing was more in traditional method compared to Happy Seeder technology used sown plot. After 20 days of sowing, it was found less in Happy seeder method. At the time of irrigation, the moisture content of soil attained to a maximum of 28.2% in both methods and then dropped to 15 % at the time of harvest.

4.12.2 Effect of Moisture Content of Sandy Soil on Days after Sowing (DAS) of Maize Crop.

The effect of moisture content of sandy soil on days after sowing (DAS) of Maize crop is shown in Fig.4.7.

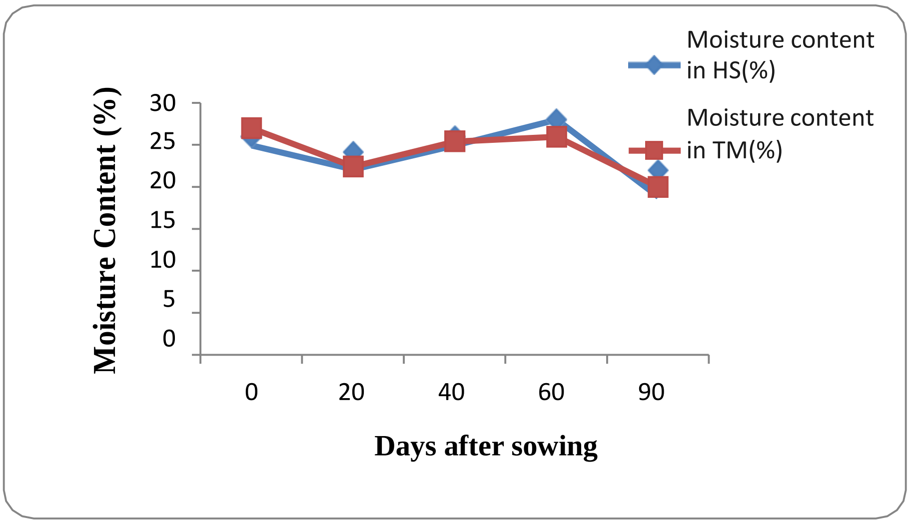


Fig.4.7 Effect of moisture content of sandy soil on days after sowing (DAS) of Maize crop

It was found that the moisture content at the time of sowing in sandy soil was more in traditional method compared to Happy Seeder sown field. After 20 days after sowing, it was found less in Happy seeder and traditional method. At the time of irrigation, the moisture content of soil attained to a maximum range of 25.5% in both the methods and then dropped to 15% at the time of harvest.

4.13 PLANT HEIGHT IN HAPPY SEEDER AND TRADITIONAL METHOD

1.Black gram

The plant height of black gram in happy seeder sown field and traditional field is given in Table 4.24.

Table 4.24 Plant height of black gram in happy seeder and traditional method

Days after sowing	Plant height(cm) of Black gram	
	Happy Seeder Technology	Traditional method
10 DAS	3-4	5-6
20 DAS	8-9	11-12
30 DAS	14-16	17-19
40 DAS	22-24	24-25
50 DAS	27-30	30-31
60 DAS	35-40	36-38
70 DAS	60-61	62-63

The graphical representation of plant height of black gram in happy seeder and traditional method is shown in Fig 4.8

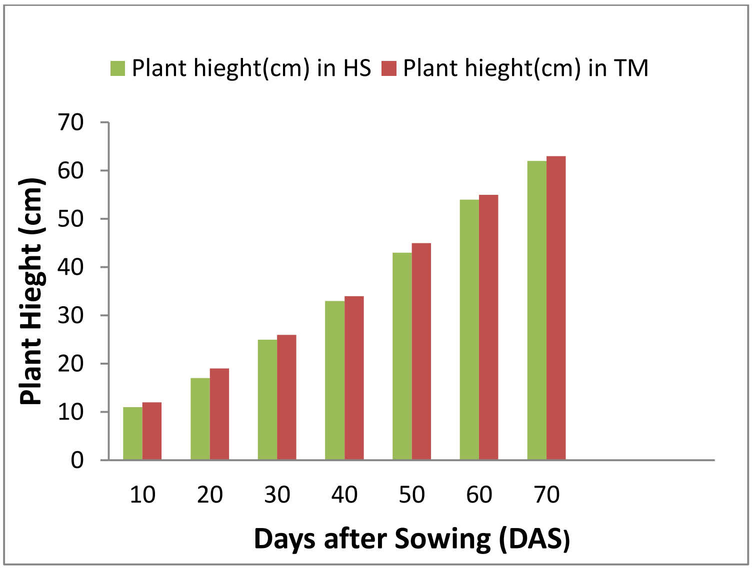


Fig.4.8 Plant height in Happy Seeder and traditional method over days after sowing of Blackgram

It was found that plant height of black gram and green gram was almost more than or equal to Traditional method with Happy Seeder technology at all the growth stages from vegetative to harvesting.

2. Green gram

The plant height of green gram in happy seeder sown field and traditional field is given in Table 4.25.

Table 4.25 Plant height of green gram in happy seeder and traditional method

Days after sowing	**Plant height(cm) of Green gram**	
	Happy Seeder Technology	**Traditional method**
After 10 Days of Sowing	2-3	4-5cm
After 20 Days of Sowing	7-8	10-11
After 30 Days of Sowing	13-15	16-18
After 40 Days of Sowing	22-23	24-27
After 50 Days of Sowing	27-30	31-33
After 60 Days of Sowing	37-40	36-38
After 70 Days of Sowing	43-44	48-49

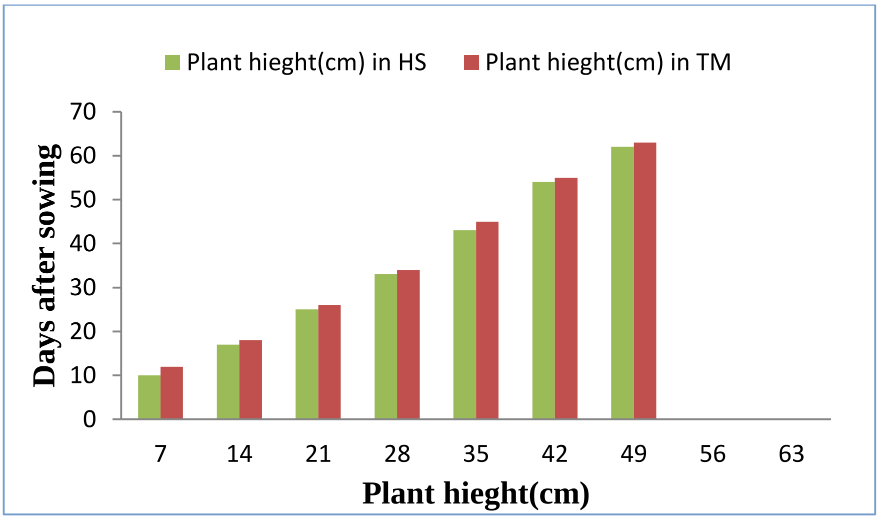


Fig.4.9 Plant height in Happy Seeder and traditional method over days after sowing of green gram

It was found that plant height of green gram was almost more or less equal to that in traditional method

3. Maize

The plant height of maize in happy seeder sown field and traditional field is given in Table 4.26.

Table 4.26 Plant height of maize in happy seeder and traditional method

Days after sowing	Plant height(cm) of Maize	
	Happy Seeder Technology	**Traditional method**
10 DAS	23-25	13-14
20 DAS	49-50	50-52
30 DAS	80-82	83-84
40 DAS	100-102	101-103
50 DAS	120-121	122-123
60 DAS	150-152	151-153
70 DAS	172-174	174-175
80 DAS	190-191	192-193
90DAS	210-213	211-212
100 DAS	230-231	233-236
110 DAS	250-251	252-254

It was found from the table that the plant height of maize was almost more or less equal in both the methods i.e. Happy Seeder and traditional method. The graphical representation of plant height of maize in Happy Seeder and traditional method is depicted in the Fig 4.10

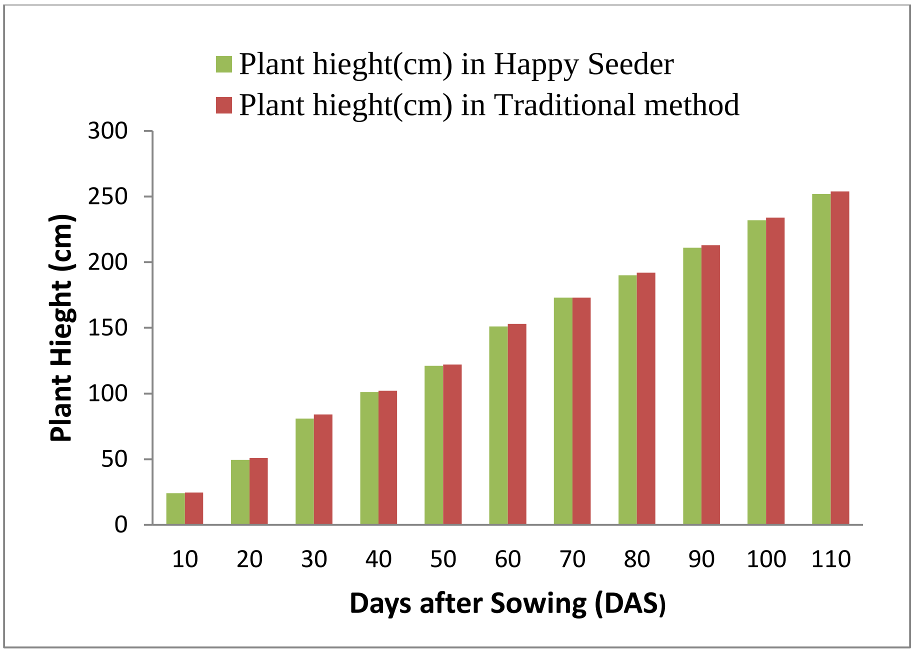


Fig 4.10 Plant height in Happy Seeder and traditional method over days after sowing of Maize

4.14 CROP GROWTH STAGES OF BLACK GRAM, GREEN GRAM AND MAIZE

1.Vegetative Stage of black gram, green gram and maize

The vegetative stage of black gram ,green gram and maize is given in Plate 4.4.

(a)

(b)

(c)

(a) Black gram; (b) Green gram; (c) Maize
Plate 4.4 Vegetative stage of Black gram, green gram and maize

2. Crop Growth stages of black gram, green gram and maize

The crop growth stage of black gram green gram and maize is given in Plate 4.5

(a)

(b)

(c)

(a) Black gram; (b) Green gram; (c) Maize

Plate 4.5 Crop growth stage of Black gram, green gram and maize

3. Harvesting stage of black gram, green gram and maize

The harvesting stage of black gram green gram and maize is given in Plate 4.6


(a)


(b)

(c)

(a) Black gram; (b) Green gram; (c) Maize

Plate 4.6 Harvesting stage of Black gram, green gram and maize

4.14 COST ECONOMICS OF HAPPY SEEDER

The total cost of sowing per acre with zero-Till Happy Seeder as well as traditional method was calculated by straight line method by summation of total fixed cost and variable cost per hour.

4.14.1Sowing with Happy Seeder

Operating cost of sowing pulses (black gram, green gram) and cereals (maize) with Zero-Till Happy Seeder was determined by considering all fixed and variable costs as explained in Appendix-D and the consolidated results were mentioned in Table 4.27.

Table 4.27 Cost economics of tractor attached to Zero-Till Happy Seeder

S.No.	Particulars	New Holland Tractor	Happy Seeder
Fixed cost			
1.	Machine Cost, Rs/-	7,500,000	1,97,000
2.	Salvage value, Rs/-	750000	19700
3.	Depreciation, Rs/- per hour	67.50	17.73
4.	Interest, Rs/- per hour	61.785	10.83
5.	Taxes, housing and insurance, Rs/- per hour	1.50	5.91
Total fixed cost, Rs/- per hour		130.87	34.47
Variable cost			
1.	Repair and maintenance, Rs/- per hour	7.50	19.7
2.	Fuel cost, Rs/- per hour	427.50	…
3.	Lubricants cost, Rs/- per hour	85.50	…
4.	Wages, Rs/- per hour	37.50	…
5.	Custom hiring charges		232.2
Total variable cost, Rs/- per hour		558	251.9
Total operating cost, Rs/- per hour		688.87	286.37
Total cost of operation of tractor with Happy seeder Rs/- per hour			**975.24**

The total fixed cost of tractor and Happy Seeder was Rs.130/- and Rs.34.47/- per hour and variable cost was Rs.688/- and 251.9/- per hour, respectively. The total operating cost of tractor operated Zero-Till Happy Seeder was Rs.975.24 /- per hour.

4.15 COST ECONOMICS OF PADDY-MAIZE CULTIVATION IN TRADITIONAL METHOD

Traditionally, maize seeds were sown manually in the dibbled holes by tractor operated five row dibbler after rotary slasher operation. The cost economics of Tractor attached with rotary slasher and dibbler is estimated in Table 4.28.

Table 4.28 Cost economics of Tractor attached with rotary slasher and dibbler in traditional method

S.No.	Particulars	SwarajTractor	Rotary slasher	Dibbler
Fixed cost, Rs/- per hour				
1.	Machine Cost	5,20,000	67,000	10,000
2.	Salvage value	52,000	6700	1,000
3.	Depreciation	46.8	30.15	4.5
4.	Interest	42.9	18.42	2.75
5.	Taxes, housing and insurance	10.4	10.05	1.5
Total fixed cost, Rs/- per hour		100.1	58.62	8.75
Variable cost, Rs/- per hour				
1.	Repair and maintenance	52.00	33.5	5.00
2.	Fuel cost	427.5	…	…
3.	Lubricants cost	85.5	…	…
4.	Wages	37.50	…	…
5.	Custom hiring charges, (capital basis)		170.23	165.
Total variable cost, Rs/- per hour		602.25	203.73	170
Total operating cost, Rs/- per hour		702.6	262.35	178.75
Total cost of operation of tractor with rotary slasher and dibbler, Rs/- per hour				**Rs.1143.7 /- hr**

The total fixed cost of tractor, rotary slasher and dibbler was estimated to be Rs.100.1/-, 58.62 and Rs.8.75 /- per hour and variable cost was Rs.602.5/-, 203.73 and 170/- per hour, respectively. The total operating cost of tractor with rotary slasher and dibbler was Rs.1143 /- per hour.

4.16 COST ECONOMICS OF PADDY-PULSE CULTIVATION IN TRADITIONAL METHOD

The cost economics of tractor attached to rotovator for tillage operations after harvesting of paddy in paddy-pulse cultivation in traditional method is given in Table 4.29

Table 4.29 Cost economics of sowing paddy-pulse in traditional method

S.No.	Particulars	SwarajTractor	Rotovator
Fixed cost			
1.	Machine Cost, Rs/-	5,20,000	200,000
2.	Salvage value, Rs/-	52000	20000
3.	Depreciation, Rs/- per hour	46.8	18.0
4.	Interest, Rs/- per hour	42.9	11.00
5.	Taxes, housing and insurance, Rs/- per hour	10.4	6.00
Total fixed cost, Rs/- per hour		100.1	35.00
Variable cost			
1.	Repair and maintenance, Rs/- per hour	52.00	20
2.	Fuel cost, Rs/- per hour	427.5	…
3.	Lubricants cost, Rs/- per hour	85.5	…
4.	Wages, Rs/- per hour	37.50	…
5.	Custom hiring charges		102.27
Total variable cost, Rs/- per hour		602.25	122.27
Total operating cost, Rs/- per hour		702.6	157.27
Total cost of operation of tractor with rotovator, Rs/- per hour			**Rs. 859.6**

The total fixed cost of tractor and rotovator was estimated to be Rs.100/- and Rs.35 /- per hour and variable cost was Rs.602.2 /- and 122/- per hour, respectively. The total operating cost of tractor with rotovator was Rs.859.6 /- per hour.

4.15 SAVINGS OF TIME AND ENERGY IN COMPARISON WITH TRADITIONAL METHODS

1. Paddy-Pulse Cultivation

There were savings in terms of fuel used, number of irrigations, man and machine hours, number of tillage operations and cost of operation in case of Paddy-Pulse intensive cultivation. The savings of time and energy of Happy Seeder in comparison with traditional method of paddy-pulse cultivation is mentioned in Table 4.30

TABLE 4.30 Savings of time and energy of Happy Seeder in comparison with traditional method of Paddy-Pulse cultivation

Parameter	Method of Sowing		
	Traditional method	Happy Seeder	% Saving
Number of tillage operations	1	0	100%
Fuel used ($l\ h^{-1}$)	4.4	4.2	6.6%
Man hours	1	0.25	75%
Machine hours	0.5	0.25	50%
Number of Irrigations	3	2	33.3

1. **Number of tillage operations**

No tillage is required for Happy Seeder sown pulse whereas traditional method required one tillage operation using rotovator in one pass after burning of residues. There was a savings of 100% in tillage operations.

2. **Reduced Fuel Economy**

There was a saving of 6.6% in fuel energy because of tillage operations by rotovator in traditional method and zero-tillage by Happy Seeder.

3. **Man hours**

There was a saving of 75% man hours in Happy Seeder method compared to the traditional method because of manual sowing followed in traditional method.

4. **Machine hours**

There was a saving of 50% machine hours in case of Happy Seeder technology compared to the traditional method of sowing in which rotovator was used as machine for tillage operations.

5. **Number of irrigations**

There was a savings of 1-2 irrigations in case of Happy Seeder technology compared to the traditional method of sowing because zero-tillage by happy seeder improves soil moisture by trapping water in the previous crop stubble and reducing runoff water**.** The trapped water provides necessary early moisture to get the crop started and surface mulching**.**

It was found that the savings in terms of time and energy consumed in the form of fuel energy, man and machine hours, number of tillage operations, electrical energy in terms of irrigations required was more in case of Happy Seeder technology compared to the traditional practice.

4.15.1 SAVINGS OF TIME AND ENERGY IN COMPARISON WITH TRADITIONAL METHOD OF PADDY-CEREAL CULTIVATION

The savings of time and energy in comparison with traditional method of paddy-cereal cultivation are given in Table 4.31

TABLE 4.31 Savings of Time and Energy in comparison with Traditional Method of Paddy-Maize Cultivation

Parameters	Method of Sowing		
	Traditional method	Happy Seeder	% Saving
Fuel Consumed ($l\ h^{-1}$)	4.3	4.2	2.3%
Man hours	2	0.25	87.5%
Machine hours	0.5	0.25	50%
Number of Irrigations	3	2	33.3

1. **Reduced Fuel Economy**

There was a saving of 2.3% of fuel consumed in happy seeder method compared to traditional method because of dibbling and land clearing operations by tractor operated 5 row dibbler in traditional method.

2. **Man hours**

There was a saving of 87.5% man hours in Happy Seeder method compared to the traditional method because of manual sowing followed in traditional method.

3. **Machine hours**

There was a saving of 50% machine hours in case of Happy Seeder technology compared to the traditional method of sowing in which tractor operated dibbler was used for dibbling operations.

4. **Number of irrigations**

There was a saving of 1-2 irrigations in case of Happy Seeder technology compared to the traditional method of sowing because zero-tillage by happy seeder improves soil moisture by trapping water in the previous crop stubble and reducing runoff water**.** The trapped water provides necessary early moisture to get the crop started and surface mulching**.**

It was found that the savings in terms of time and energy consumed in the form of fuel energy, man and machine hours, number of tillage operations, electrical energy in terms of irrigations required was more in case of Happy Seeder technology compared to the traditional practice.

CHAPTER - V

SUMMARY AND CONCLUSIONS

Stubble management in combine used paddy field is one of the complex issues that farmers are facing in the Andhra Pradesh region. Traditionally, farmers prefer to burn previous crop residues for the sowing of next crop i.e. pulses and cereals to manage heavy stubbles, invasive weeds or pests as there is narrow gap between harvesting of paddy and sowing of next succeeding crop. Burning of paddy residues has a negative impact on people's health, crop output and cause lot of environmental pollution. Happy Seeder is an alternative solution to tackle this problem. Adopting innovative farm mechanization techniques enhances the overall productivity, reduces pollution related problems, lowers the cost of production in agriculture. Farmers are burning away the paddy straw assuming it to be quick and easy for disposing which enables them to plant the next crop well in time. Happy seeder technology is the greatest solution of residue management and direct seeding of pulses like black gram, green gram and cereals like maize in paddy harvested fields.

A Zero-Till Happy Seeder was tested for its feasibility under three different soil conditions in Andhra Pradesh region taking three crops (Black gram, Green gram and Maize) was reference at Research farm of Agricultural College, Bapatla. The performance of the Happy seeder concerning actual field capacity, theoretical field capacity, field efficiency, draft, fuel consumption, ground wheel slippage, speed index, cost of operation and crop residue condition were studied and compared to a conventional method.Based on the results obtained as the following conclusions were drawn.

1. The developed four different types furrow closers namely L-Type blade at 30°inclination, L-Type blade at 120° inclination, Roller and Double Wheel type revealed that depth of furrow coverage of double wheel and L-Type blade at 120° inclination type furrow closers showed significant results. The other two i.e. roller and L-Type blade at 30°inclination were non-significance and not efficient for closing the furrows.
2. Happy Seeder found its suitability for sowing crops like Black gram, Green gram and Maize in different soil types namely Black, Clay loam and Sandy soil.
3. Field efficiency was found more in Sandy soil i.e. 63.07% followed by sandy loam with 62% and black soil with 60%.

4. Field capacity increased with increase in forward speed thereafter it decreased,
5. The actual working width of Zero-Till Happy Seeder was found to be 225 cm.
6. The maximum draft observed was 6.64kN at a depth of 7.2 cm in Black soil whereas in case of sandy soil, it was 4.68kN at a depth of 6.7cm and in clay loam soil it was 5.42 kN at a depth of 6.3cm.
7. The ground drive wheel slip of Happy Seeder was found more in sandy soil with 6.5% because of lower resistance produced in the lugs of ground wheel causing more slip whereas in clay loam it was less i.e. 3.5% due to more traction provided to the lugs due its compact soil structure
8. The wheel slip of tractor was found more i.e. 4% in black soil because of of more moisture in the soil causing more wheel slip whereas in sandy it was less i.e. 2% due to less moisture enabling the wheel to cause no loose soil clods and the tractor wheel to produce more traction causing it to roll at the same place.
9. The power requirement of Happy Seeder was more i.e. 13.27 hp in black soil and 11.05 hp in clay loam and 10.18 hp in sandy soil.
10. The speed index was found more in sandy soil i.e. 0.25 indicating less clogging of soil in the straw management rotor followed by clay loam with of 0.19 and black soil with a value of 0.17.
11. The fuel consumption increased linearly with an increase in the speed of seeder within the tested speed ranges.
12. At speed of 3 km h^{-1} obtained best results of field efficiency, fuel consumption and ground wheel slip in sandy, clay loam and black soil.
13. The overall cost of operation for Zero-Till Happy Seeder was Rs.975.24 /- per hour whereas for paddy- maize traditional method it was Rs. 1143 /- per hour
14. The overall cost of operation for Zero-Till Happy Seeder was Rs.975.24 /- per hour whereas for paddy- pulse traditional method it was Rs 859.6/- per hour.
15. Moisture content at the time of sowing in clay loam soil was more i.e 25.4% in TM (traditional method) compared to 25% in HS (Happy Seeder) technology sown plot because it took time for straw retention to conserve moisture due to straw residues. After 20 days of sowing, moisture content dropped in both fields .Then after 40 days of sowing, moisture content reached to a peak value of 28% in HS because of irrigation period. At the time of irrigation, the moisture content of soil attained to a

maximum value of 29.2% in both methods and then dropped to 15.5%at the time of harvest.

16. The moisture content of clay loam soil at the time of sowing was more in traditional method compared to Happy Seeder technology sown plot. After 20 days of sowing, it was found less in Happy seeder method. At the time of irrigation, the moisture content of soil attained to a maximum range of 28.2% in both methods and then dropped to 15 % at the time of harvest.
17. The moisture content at the time of sowing in sandy soil was more in traditional method compared to Happy Seeder sown field. After 20 days of sowing, it was found less in Happy seeder and traditional method. At the time of irrigation, the moisture content of soil attained to a maximum range of 25.5% in both the methods and then dropped to 15% at the time of harvest.
18. Plant height of green gram, black gram and maize was almost more or less equal to that in traditional method compared to Happy Seeder technology.
19. There was a saving of 100%, 6.6%, 75%, 50% and 33.3% in Happy Seeder method compared to traditional method of paddy-pulse cultivation in terms of tillage operations, fuel used, man and machine hours and number of irrigations, respectively.
20. There was a saving of 2.3%, 87.5%, 50%, and 33.3% in Happy Seeder method compared to traditional method of paddy-cereal (maize) cultivation in terms of fuel used, man and machine hours and number of irrigations, respectively.

SUGGESTIONS FOR FUTURE WORK

The following suggestions for future work for development of Zero-Till Happy Seeder under different soil conditions are given below;

1. Slasher operation may be incorporated with Happy Seeder to avoid competition of weeds and better seed planting
2. Provision should be made for preventing clogging of soil around the straw management rotor like scrapers.
3. Row to row spacing should be adjustable in case of Maize planting because this crop requires more row spacing of 30cm.
4. Feasibility testing of Happy Seeder for different fiber and oilseed crops should be studied under different soil conditions of Andhra Pradesh region

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APPENDIX-A

Table.1 Specifications of Zero-Till Happy Seeder used in the Study

Parameters/Particulars	Specifications/Observations
Model	National
Manufacturers	National Agro industries
Serial No.	NHS-001
Colour	Green and yellow
Machine Length (mm)	2250
Machine Width (mm)	1370
Machine Height (mm)	1510
Horse Power Requirement, Hp	50
Operational mass, kg	650
Weight (kg)	550
Working width of machine, mm	2230
Straw management drum	
Rotor drum diameter, mm	750
Number of flail blades	20
Rotor diameter, mm	140
Rotor shaft speed at 540 rpm of PTO Shaft	1450
Flail blades	
Types of flail blades	Inverted gamma type
No. of flail blades	20
Flail length from rotor surface, mm	240
Blade length, mm	165
Top width of blade, mm	50
Bottom width of blade, mm	85
Blade overlap with furrow openers, mm	60
Thickness of flail blades, mm	80

Horizontal clearance between the edges of blades, mm	75
Depth wheel	
No. of Depth wheels	2
Adjustment of depth wheel	Jack type
Diameter of Ground Wheel, mm	550
No. of lugs on the periphery of GW	15 (with sharp and long rectangular edges)
No. of rows	10
Row to row Spacing, cm	22.5
Type of Furrow openers	Inverted 'T' type
Type of Hitching	3-Point Linkage
Power Transmission System for Rotor Unit	
Primary Reduction	Spur and Bevel gears Combination
Secondary Reduction	Chain and Sprocket arrangement
3-Point linkage	
Mast height, mm	140
Lower hitch point span, mm	40
No. of adjusting pins	3

APPENDIX-B

Table 2.SPECIFICATIONS OF ROTARY SLASHER USED IN THE STUDY

Specifications	Observations, mm
Overall size (Lx B x H)	1428x 1825x963
Working width (mm)	1200
Horse Power (HP)	35-45
PTO Power Requirement	30-38
PTO input Speed (rpm)	540
Weight (kg/lbs)	306/675
Chains/Blades	3/2
Cutting height	25-150
Guards	Rubber flap
Blade Rpm	1012

Table 3. Specifications of New Holland 4710 Tractor used in the Evaluation

Brand	New Holland
Model	New Holland 4710
No. of Cylinder	3
Tractor HP	47
PTO HP	43
Gear Box	Synchromesh
Brakes	Oil Immersed
Specific fuel Consumption	147g/hp-h

APPENDIX -C

A. Univariate Analysis of variance applied to different furrow closers attached to Happy Seeder

1.L-type blade at 30º inclination

Tests of Between-Subjects Effects

Dependent Variable: Depth of furrow coverage, L-30 Blade					
Source	**Type III Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Corrected Model	5.002[a]	3	1.667	31.884	0.100
Intercept	124.881	1	124.881	2388.155	0.00
speed	5.002	3	1.667	31.884	.000
Error	.628	12	.052		
Total	130.510	16			
Corrected Total	5.629	15			

a. R Squared = .889 (Adjusted R Squared = .861)

2. L-type blade at 120° inclination

Tests of Between-Subjects Effects

Dependent Variable: Depth of Furrow coverage, L-120 Blade

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	6.208[a]	3	2.069	225.727	.000
Intercept	280.563	1	280.563	30606.818	.000
speed	6.208	3	2.069	225.727	.000
Error	.110	12	.009		
Total	286.880	16			
Corrected Total	6.318	15			

a. R Squared = .983 (Adjusted R Squared = .978)

3. Roller type furrow closer

Tests of Between-Subjects Effects

Dependent Variable: Depth of Furrow Coverage, Roller type

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	.895[a]	3	.298	37.684	.080
Intercept	30.250	1	30.250	3821.053	.000
speed	.895	3	.298	277.684	.000
Error	.095	12	.008		
Total	31.240	16			
Corrected Total	.990	15			

R Squared = .904 (Adjusted R Squared = .880)

4. Double Wheel Type furrow closer

Tests of Between-Subjects Effects

Dependent Variable: Depth of Furrow coverage, Double Wheel type furrow

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	4.110[a]	3	1.370	205.500	.000
Intercept	278.890	1	278.890	41833.500	.000
speed	4.110	3	1.370	205.500	.000
Error	.080	12	.007		
Total	283.080	16			
Corrected Total	4.190	15			

APPENDIX-D

Cost Economics of Happy Seeder operation

The following data were considered for determining the cost economics of tractor for sowing operation

Initial cost of New Holland 4710 tractor	: Rs 7,50,000.00
Life of machine	: 10 years
Salvage value	: 10 %
Interest rate	: 15 %
Shelter and insurance	: 2 % of purchase price
Annual use of Happy Seeder	: 1000 h
Depreciation	: Straight line method

I. Cost for operating the tractor for sowing operation

a. Annual Fixed cost

i) Depreciation (D)

The annual depreciation value can be calculated by the following equation

$$D = \frac{P - S}{L \times H}$$

Where,

D = depreciation (Rs h^{-1})
P = purchase price (Rs h^{-1})
S = salvage value, 10% of purchase price
L = life of the machine (years)
H = number of working hours per year

$$\frac{7,50,000-75,000}{10\times1000} = 67.50 \text{ Rs h}^{-1}$$

ii) Interest (I)

Annual interest is calculated by the following expression

$$I=\frac{C+S}{2}\times\frac{i}{H}$$

Where,

I = annual interest charge (Rs h^{-1})
i = interest rate (per cent)

$$I = \frac{7,50,000 + 75,000}{2}\times\frac{0.15}{1000} = 61.875 \text{ Rs h}^{-1}$$

iii) Taxes, housing and insurance

Shelter and insurance cost was taken 2 per cent of the purchase price of the machine per year.

$$= \frac{0.02\times 75,000}{1000} = 1.50 \text{ Rs h}^{-1}$$

Total fixed cost = i + ii + iii

$$= 67.50 + 61.875 + 1.50 = 130.875 \text{ Rs h}^{-1}$$

b. Operating Cost

i. Repair and maintenance cost

Repair and maintenance cost was taken 10 per cent of the purchase price of tractor per year

$$\text{Repair and maintenance costs} = \frac{0.10\times 7,50,000}{1000} = 7.50 \text{ Rs h}^{-1}$$

ii. Fuel costs

Cost of fuel per litre taken = 95 Rs l^{-1}

Fuel required for one hour = 4.22 l h^{-1}

Fuel cost = 95 × 4.50 = 427.50 Rs h^{-1}

iii. Lubrication costs

Charge of lubricants was taken 20 per cent of total fuel costs

Lubricants costs = 427 .50 × 0.20 = 85.50 Rs h^{-1}

iv. Operating charge

The cost of operator was taken for tractor driving based on the labour charge paid per day. Rs. 500 day^{-1} was paid for tractor operator and 8 hours taken for one day.

$$\text{Operating charge} = \frac{500.00}{8} = 37.50 \text{ Rs h}^{-1}$$

Total operating cost = i + ii + iii + iv

= 7.50 + 427.50 + 85.50 + 37.50 = 558.00 Rs h^{-1}

Total cost of operation of tractor = a + b

= 130.875 + 558.00

= 688.875 ≈ 689.00 Rs h^{-1}

II. Cost of operation tractor operated Happy Seeder

a. Annual fixed cost

i) Depreciation (D):

The annual depreciation value can be calculated by the following equation

$$D = \frac{P - S}{L \times H}$$

Where,

D = depreciation (Rs h^{-1})
P = purchase price (Rs h^{-1})
S = salvage value, 10% of purchase price
L = life of the machine (years)
H = number of working hours per year

1. Depreciation $= \frac{C-s}{LxH}$

$$=\frac{1,97000-19700}{10X1000}$$

=Rs.17.73 per hour

2. Interest $=\frac{C+S}{2}X\frac{i}{H}$

$$=\frac{197000+19700}{2}X\frac{0.1}{1000}$$

=Rs.10.83/- per hour

3. Taxes, housing and Insurance = $\frac{3\%\ of\ Initial\ cost\ of\ machine}{Annual\ use\ of\ Machine}$

=Rs. 5.91/- per hour

Total fixed cost = i + ii + iii

= 17.73 + 10.83 + 5.91 = Rs.34.47/- per hour

b. Operating cost

i. Repair and maintenance cost

Repair and maintenance cost was taken 10 per cent of the purchase price of machine per year

$$\text{Repair and maintenance costs} = \frac{0.10\times 197000}{1000} = 19.7\text{Rs h}^{-1}$$

Total cost of operation of tractor operated rotavator = a + b

= 34.47 + 19.7

= 54.17 Rs h^{-1}

The total cost of operation = Total cost of operating the tractor + Total cost of operating rotovator

= 689 + 54.17

=743.17 Rs h^{-1}

Effective field capacity of tractor operated Happy Seeder was 0.42 ha h^{-1}. Hence cost of operation per hectare.

$$\text{Cost of operation} = \frac{743.17}{0.4} = 1857.4761 \text{ Rs ha}^{-1}$$

Over head charges, at 25 per cent of the total cost of operation = 185.79 Rs h^{-1}

Profit, at 25 per cent of the overhead charges = 46.44Rs h^{-1}

Custom hiring charges, = 232.2Rs h^{-1}

APPENDIX-E

Economics of tractor for sowing of paddy-pulse in Traditional Method

The following data were considered for determining the cost economics of sowing of paddy-pulse in Traditional Method.

Initial cost of tractor	: Rs 2,50,000.00
Life of machine	: 10 years
Salvage value	: 10 %
Interest rate	: 15 %
Shelter and insurance	: 2 % of purchase price
Annual use of rotovator	: 800 h
Depreciation	: Straight line method

I. Cost for operating the tractor

a. Annual fixed cost

i. Depreciation

The annual depreciation value can be calculated by the following equation

$$D = \frac{P - S}{L \times H}$$

Where,

D = depreciation (Rs h^{-1})
P = purchase price (Rs h^{-1})
S = salvage value, 10% of purchase price
L = life of the machine (years)
H = number of working hours per year

$$\frac{2{,}50{,}000-25{,}000}{10 \times 800} = 28.125 \text{ Rs h}^{-1}$$

ii Interest

Annual interest is calculated by the following expression

$$I = \frac{P+S}{2} \times \frac{i}{H}$$

Where,

I = annual interest charge (Rs h^{-1})

i = interest rate (per cent)

$$I = \frac{2,50,000 + 25,000}{2} \times \frac{0.15}{800} = 25.78 \text{ Rs h}^{-1}$$

iii. Shelter and insurance

Shelter and insurance cost was taken 2 per cent of the purchase price of the machine per year.

$$= \frac{0.02 \times 25,000}{800} = 0.625 \text{ Rs h}^{-1}$$

Total fixed cost = i + ii + iii

= 28.125 + 25.78 + 0.625 = 8.99 = 54.53 Rs h^{-1}

b. Operating cost

i. Repair and maintenance cost

Repair and maintenance cost was taken 10 per cent of the purchase price of machine per year

$$\text{Repair and maintenance costs} = \frac{0.10 \times 2,50,000}{800} = 31.25 \text{ Rs h}^{-1}$$

ii. Fuel costs

Cost of fuel per litre taken = 95 Rs l^{-1}

Fuel required for one hour = 1.50 l h^{-1}

Fuel cost = 95 × 1.50 = 142.50 Rs h^{-1}

iii. Lubrication costs

Charge of lubricants was taken 20 per cent of total fuel costs

Lubricants costs = 142.50 × 0.20 = 28.50 Rs h^{-1}

iv. Operating charge

The cost of operator was taken for remote operating based on the labour charge paid per day. Rs. 300 day^{-1} was paid for automated power tiller operator and 8 hours taken for one day.

$$\text{Operating charge} = \frac{300.00}{8} = 37.50 \text{ Rs h}^{-1}$$

Total operating cost = i + ii + iii + iv

= 31.25 + 142.50 + 28.50 + 37.50= 272.75 Rs h^{-1}

Total cost of operating automated power tiller for puddling operation = a + b

= 54.53 + 272.75

= 327.28 Rs h^{-1}

Breakeven point, h $annum^{-1}$

$$= \frac{\textbf{Annual fixed costs, (Rs h}^{-1}\textbf{)}}{\textbf{Custom hiring charges,(Rs h}^{-1}\textbf{)-Total operating costs, (Rs h}^{-1}\textbf{)}}$$

Effective field capacity of automated power tiller for puddling operation was 0.072 ha h^{-1}. Hence cost of operation per hectare.

$$\text{Cost of operation} = \frac{350.28}{0.072} = 4865.00 \text{ Rs ha}^{-1}$$

Over head charges, at 25 per cent of the total cost of operation = 87.57 Rs h^{-1}

Profit, at 25 per cent of the overhead charges = 21.89 Rs h^{-1}

Custom hiring charges, = 459.74 Rs h^{-1}

APPENDIX-F

Cost Economics of Paddy-cereal cultivation traditional method

Cost economics of tractor attached for rotary slasher for shredding operation

The following data were considered for determining the cost economics of tractor attached with rotary slasher for shredding operation and dibbler for punching operation.

Initial cost of Mahindra 575DI	: Rs 5,20,000.00
Life of machine	: 10 years
Salvage value	: 10 %
Interest rate	: 15 %
Shelter and insurance	: 2 % of purchase price
Annual use of tractor	: 1000 h
Depreciation	: Straight line method

I. Cost for operating the tractor with rotary slasher for shredding operation

a. Annual Fixed cost

i) Depreciation (D)

The annual depreciation value can be calculated by the following equation

$$D = \frac{P - S}{L \times H}$$

Where,

D = depreciation (Rs h^{-1})
P = purchase price (Rs h^{-1})
S = salvage value, 10% of purchase price
L = life of the machine (years)
H = number of working hours per year

$$\frac{5,20,000-52,000}{10 \times 1000} = 46.8 \text{ Rs h}^{-1}$$

ii) Interest (I)

Annual interest is calculated by the following expression

$$I = \frac{C+S}{2} \times \frac{i}{H}$$

Where,

I = annual interest charge (Rs h^{-1})
i = interest rate (per cent)

$$I = \frac{5,20,000 + 52,000}{2} \times \frac{0.15}{1000} = 42.9 \text{ Rs } h^{-1}$$

iii) Taxes, housing and insurance

Shelter and insurance cost was taken 2 per cent of the purchase price of the machine per year.

$$= \frac{0.02 \times 520,000}{1000} = 10.4 \text{ Rs } h^{-1}$$

Total fixed cost = i + ii + iii

= 46.8 + 42.9 + 10.4 = 100.1 Rs h^{-1}

b. Operating Cost

i. Repair and maintenance cost

Repair and maintenance cost was taken 10 per cent of the purchase price of tractor per year

$$\text{Repair and maintenance costs} = \frac{0.10 \times 5,20,000}{1000} = 52 \text{ Rs } h^{-1}$$

ii. Fuel costs

Cost of fuel per litre = 95 Rs l^{-1}

Fuel required = 4.5 l h^{-1}

Fuel cost = 95 × 4.5 = 285= 427.5Rs h^{-1}

iii. Lubrication costs

Charge of lubricants was taken 20 per cent of total fuel costs

Lubricants costs = 427.5 × 0.20 = 85.5 Rs h^{-1}

iv. Operating charge

The cost of operator was taken for tractor driving based on the labour charge paid per day. Rs. 500 day^{-1} was paid for tractor operator and 8 hours taken for one day.

$$\text{Operating charge} = \frac{500.00}{8} = 37.50 \text{ Rs h}^{-1}$$

Total operating cost = i + ii + iii + iv

= 52 + 285+ 57 + 37.50 = 431 Rs h^{-1}

Total cost of operation of tractor = a + b

= 100.1 + 431.00

= 531.1Rs h^{-1}

II. Cost of operation tractor operated rotary slasher

a. Annual fixed cost

i) Depreciation (D):

The annual depreciation value can be calculated by the following equation

$$D = \frac{P - S}{L \times H}$$

Where,

D = depreciation (Rs h^{-1})
P = purchase price (Rs h^{-1})
S = salvage value, 10% of purchase price
L = life of the machine (years)
H = number of working hours per year

1. **Depreciation** $= \frac{C-S}{LxH}$

$$=\frac{67000-6700}{10X200}$$

=Rs.30.15 per hour

2. **Interest** $= \frac{C+S}{2} X \frac{i}{H}$

$$= \frac{67000+6700}{2} X \frac{0.1}{200}$$

=Rs.18.42/- per hour

3. **Taxes, housing and Insurance** = $\frac{3\% \text{ of Initial cost of machine}}{\text{Annual use of Machine}}$

=Rs. 10.05/- per hour

Total fixed cost = i + ii + iii

= 30.15 +18.42 +10.05 = Rs.58.62 /- per hour

b. Operating cost

i. Repair and maintenance cost

Repair and maintenance cost was taken 10 per cent of the purchase price of machine per year

$$\text{Repair and maintenance costs} = \frac{0.10\times 67000}{200} = 33.5 \text{Rs h}^{-1}$$

Total cost of operation of tractor operated rotary slasher = a + b

= 58.62 + 33.5

= 92.12 Rs h^{-1}

The total cost of operation = Total cost of operating the tractor + Total cost of operating rotary slasher

= 531 + 92.12

= 623.12 Rs h^{-1}

Effective field capacity of tractor operated rotary slasher was 0.533 ha h^{-1}. Hence cost of operation per hectare.

$$\text{Cost of operation} = \frac{623.12}{0.533} = 1169.08 \text{ Rs ha}^{-1}$$

Over head charges, at 25 per cent of the total cost of operation = 155.78Rs h^{-1}

Profit, at 25 per cent of the overhead charges = 38.94 Rs h^{-1}

Custom hiring charges, = 194.72 Rs h^{-1}

Cost Economics of tractor attached with dibbler for punching operation

The following data were considered for determining the cost economics of tractor attached with dibbler for punching operation

Initial cost of Mahindra 575DI	: Rs 5,20,000.00
Life of machine	: 10 years
Salvage value	: 10 %
Interest rate	: 15 %
Shelter and insurance	: 2 % of purchase price
Annual use of tractor	: 1000 h
Depreciation	: Straight line method

I. Cost for operating the tractor with dibbler for punching operation

a. Annual Fixed cost

i) Depreciation (D)

The annual depreciation value can be calculated by the following equation

$$D = \frac{P - S}{L \times H}$$

Where,

D = depreciation (Rs h^{-1})
P = purchase price (Rs h^{-1})
S = salvage value, 10% of purchase price
L = life of the machine (years)
H = number of working hours per year

$$\frac{5{,}20{,}000-52{,}000}{10\times1000} = 46.8 \text{ Rs h}^{-1}$$

ii) Interest (I)

Annual interest is calculated by the following expression

$$I=\frac{C+S}{2}\times\frac{i}{H}$$

Where,

I = annual interest charge (Rs h^{-1})

i = interest rate (per cent)

$$I = \frac{5{,}20{,}000 + 52{,}000}{2}\times\frac{0.15}{1000} = 42.9 \text{ Rs h}^{-1}$$

iii) Taxes, housing and insurance

Shelter and insurance cost was taken 2 per cent of the purchase price of the machine per year.

$$= \frac{0.02\times 520{,}000}{1000} = 10.4 \text{ Rs h}^{-1}$$

Total fixed cost = i + ii + iii

$$= 46.8 + 42.9 + 10.4 = 100.1 \text{ Rs h}^{-1}$$

b. Operating Cost

i. Repair and maintenance cost

Repair and maintenance cost was taken 10 per cent of the purchase price of tractor per year

$$\text{Repair and maintenance costs} = \frac{0.10\times 5{,}20{,}000}{1000} = 52 \text{ Rs h}^{-1}$$

ii. Fuel costs

Cost of fuel per litre = 95 Rs l^{-1}

Fuel required for one hour = 3 l h^{-1}

Fuel cost = 95 × 4.5 = 285= 427.5Rs h^{-1}

iii. Lubrication costs

Charge of lubricants was taken 20 per cent of total fuel costs

Lubricants costs = 427.5 × 0.20 = 85.5 Rs h^{-1}

iv. Operating charge

The cost of operator was taken for tractor driving based on the labour charge paid per day. Rs. 500 day^{-1} was paid for tractor operator and 8 hours taken for one day.

$$\text{Operating charge} = \frac{500.00}{8} = 37.50 \text{ Rs h}^{-1}$$

Total operating cost = i + ii + iii + iv

= 52 + 285+ 57 + 37.50 = 431 Rs h^{-1}

Total cost of operation of tractor = a + b

= 100.1 + 431.00

= 531.1Rs h^{-1}

II. Cost of operation tractor operated dibbler

a. Annual fixed cost

i) Depreciation (D):

The annual depreciation value can be calculated by the following equation

$$D = \frac{P - S}{L \times H}$$

Where,

D = depreciation (Rs h^{-1})
P = purchase price (Rs h^{-1})
S = salvage value, 10% of purchase price

L = life of the machine (years)

H = number of working hours per year

1. **Depreciation** $= \frac{C-s}{LxH}$

$= \frac{10000-1000}{10X200}$

=Rs.4.5 per hour

2. **Interest** $= \frac{C+S}{2} X \frac{i}{H}$

$= \frac{10000+1000}{2} X \frac{0.1}{200}$

=Rs.2.75 /- per hour

3. **Taxes, housing and Insurance** = $\frac{\text{3\% of Initial cost of machine}}{\text{Annual use of Machine}}$

=Rs. 1.5/- per hour

Total fixed cost = i + ii + iii

= 4.5+2.75+1.5 = Rs.8.75 /- per hour

b. Operating cost

i. Repair and maintenance cost

Repair and maintenance cost was taken 10 per cent of the purchase price of machine per year

$$\text{Repair and maintenance costs} = \frac{0.10 \times 10000}{200} = 5 \text{Rs h}^{-1}$$

Total cost of operation of tractor operated dibbler= a + b

= 8.75 + 5.00

= 13.75Rs h^{-1}

The total cost of operation = Total cost of operating the tractor + Total cost of operating dibbler

= 531 + 13.75

= 544.75Rs h^{-1}

Over head charges, at 25 per cent of the total cost of operation = 136.17Rs h^{-1}

Profit, at 25 per cent of the overhead charges = 34.04 Rs h^{-1}

Custom hiring charges, = 170.04Rs h^{-1}

APPENDIX-III

Economics of tractor for sowing of paddy-pulse in Traditional Method

The following data were considered for determining the cost economics of sowing of paddy-pulse in Traditional Method.

Initial cost of tractor	: Rs 2,50,000.00
Life of machine	: 10 years
Salvage value	: 10 %
Interest rate	: 15 %
Shelter and insurance	: 2 % of purchase price
Annual use of rotovator	: 800 h
Depreciation	: Straight line method

I. Cost for operating the tractor operated rotovator

a. Annual fixed cost

i. Depreciation

The annual depreciation value can be calculated by the following equation

$$D = \frac{P - S}{L \times H}$$

Where,

D = depreciation (Rs h^{-1})
P = purchase price (Rs h^{-1})
S = salvage value, 10% of purchase price
L = life of the machine (years)
H = number of working hours per year

$$\frac{2,50,000-25,000}{10 \times 800} = 28.125 \text{ Rs } h^{-1}$$

ii Interest

Annual interest is calculated by the following expression

$$I = \frac{P+S}{2} \times \frac{i}{H}$$

Where,

I = annual interest charge (Rs h^{-1})

i = interest rate (per cent)

$$I = \frac{2{,}50{,}000 + 25{,}000}{2} \times \frac{0.15}{800} = 25.78 \text{ Rs h}^{-1}$$

iii. Shelter and insurance

Shelter and insurance cost was taken 2 per cent of the purchase price of the machine per year.

$$= \frac{0.02 \times 25{,}000}{800} = 0.625 \text{ Rs h}^{-1}$$

Total fixed cost = i + ii + iii

= 28.125 + 25.78 + 0.625 = 8.99 = 54.53 Rs h^{-1}

b. Operating cost

i. Repair and maintenance cost

Repair and maintenance cost was taken 10 per cent of the purchase price of machine per year

$$\text{Repair and maintenance costs} = \frac{0.10 \times 2{,}50{,}000}{800} = 31.25 \text{ Rs h}^{-1}$$

ii. Fuel costs

Cost of fuel per litre taken = 95 Rs l^{-1}

Fuel required for one hour = 1.50 l h^{-1}

Fuel cost = 95 × 1.50 = 142.50 Rs h^{-1}

iii. Lubrication costs

Charge of lubricants was taken 20 per cent of total fuel costs

Lubricants costs = 142.50 × 0.20 = 28.50 Rs h^{-1}

iv. Operating charge

The cost of operator was taken for remote operating based on the labour charge paid per day. Rs. 300 day^{-1} was paid for automated power tiller operator and 8 hours taken for one day.

$$\text{Operating charge} = \frac{300.00}{8} = 37.50 \text{ Rs h}^{-1}$$

Total operating cost = i + ii + iii + iv

= 31.25 + 142.50 + 28.50 + 37.50= 272.75 Rs h^{-1}

Total cost of operating operation = a + b

= 54.53 + 272.75

= 327.28 Rs h^{-1}

Effective field capacity of rotovator for tillage operation was 0.072 ha h^{-1}. Hence cost of operation per hectare.

$$\text{Cost of operation} = \frac{350.28}{0.072} = 4865.00 \text{ Rs ha}^{-1}$$

Custom Hiring charges

Over head charges, at 25 per cent of the total cost of operation = 81.82 Rs h^{-1}

Profit, at 25 per cent of the overhead charges = 20.455 Rs h^{-1}

Custom hiring charges, = 102.275 ≈ 103.00 Rs h^{-1}