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Assessment of Wheat Crop Using Mechanized and Coventional Practices at Directorate of Agricultural Research (DoAR), Tarahara, Susari, Nepal

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ABSTRACT
The mechanization of wheat farming in Nepal today has increased, making it an important component of the agricultural industry. Since the majority of farmers in Nepal still use conventional farming techniques, mechanization in wheat production is still in its infancy. But in recent years, the Nepal government has pushed for the adoption of cutting-edge agricultural technologies, such as farm mechanization, to boost the yield of wheat and other crops. The formation of the Directorate of Agricultural Research (DoAR), Tarahara under Nepal Agricultural Research Council played a significant role in pushing up the rising trend of productivity. The main objective of this research is to examine the impact of farm mechanization on wheat productivity (mainly Super Seeder, Rotavators or Farmer's Practice and Zero-Till Seed cum Fertilizer Drill). Compared to modern farming methods, traditional farming practices are less productive, which reduces yields and revenue. Additionally, it might not have sufficient methods for managing pests and diseases, which would lead to crop losses and lower yields. It takes a lot of manual labor, which may be physically taxing and time-consuming, and are frequently labor-intensive. In order to address these issues, in this study we undertook three plots where we employed a super seeder, rotavator and zero-till seed cum fertilizer drill for wheat seed establishment in the DoAR field. Experiments were carried out in ten sample with three treatments in 5680 m^2 plot area. BL4341 variety of wheat seed was used to sow at the seed rate of 120 kg/ha. DAP, Urea and Potash fertilizer were used N:P:K @ 100:60:40 kg /ha and pre herbicides such as Glyphosate and post pendimethaline, 2-4-D were used. The highest yield of 3426.9 kg/ha was obtained in treatment (T1) where super seeder was used for wheat cultivation followed by farmer's practice of 3061.8 kg/ha. The lowest yield of 2484.4 kg/ha was obtained where zero-till seed cum fertilizer drill was used for wheat cultivation. The yield using super seeder was 11.14% higher than the farmer's practice and cost of production was 2.78% lower than FP. The highest benefit-cost ratio was found in using super seeder of 2.44 and that of zero-till seed cum fertilizer drill and farmers practice was 1.39 and 0.2. Thus, the application of these modern mechanized agricultural machinery is found better and profitable in the study area.
Key words: Mechanization, wheat, Traditional Practices, Economic Analysis, Gross Margin, Benefit-Cost Ratio.

I. INTRODUCTION

One of the basic foods of Nepal is wheat, a significant grain crop farmed around the world. The mountainous and Terai regions of Nepal have the highest concentration of wheat growing, which is a significant cash crop for local farmers. Wheat farming in Nepal has a long history that begins with the introduction of the crop by traders and visitors from nearby nations. As food consumption has increased, wheat planting has increased and has become a significant component of the Nepalese diet. Between November and April, Nepal's winter growing season, wheat is commonly cultivated there. The Terai region and middle hills regions make up the majority of Nepal's wheat-growing regions.

The Ministry of Agriculture and Livestock Development (MoALD) reports that Nepal's production of wheat climbed from 1.3 million metric tons in 2015–16 to 1.6 million metric tons in 2020–21. According to the economic survey results for 2019, Nepal produced 1786 tons of wheat, up from 265 tonnes in 1970, with an annual growth rate of 4.74% (*STATISTICAL-INFORMATION-ON-NEPALESE-AGRICULTURE-2077-78*). The hilly and mountainous portions of Nepal, then the Terai region, provide the majority of the country's wheat. Jhapa (4.16 MT/ha), Bhaktapur (4.55 MT/ha), Nawalparasi east (3.60 MT/ha), Bardiya (4.37 MT/ha), Surkhet (3.38 MT/ha) and Kailali (4.03 MT/ha) are the principal wheat-growing districts from each province in Nepal (MoALD, 2020/21).

There are a number of difficulties with wheat farming in Nepal, including low productivity, and restricted access to contemporary farming methods and technologies. The distribution of high-yielding wheat varieties, instruction in contemporary farming methods for farmers, and the provision of subsidies for inputs like fertilizer and seeds are just a few of the measures the government of Nepal has done to encourage wheat cultivation and boost its productivity. The Nepal government has been enacting a number of programs and regulations. Inputs like fertilizer and seeds are subsidized, high-yielding wheat varieties are distributed, and farmers are trained in contemporary agricultural methods. In conclusion, wheat farming is a significant component of Nepali agriculture and is essential to the security of the nation's food supply. Despite the difficulties experienced by farmers, it is anticipated that government measures to promote wheat growing will enhance productivity and improve farmers' living conditions.

The agricultural industry in Nepal has a long history, and many old farming techniques are still in use. Modern agricultural machinery has, however, only recently and somewhat slowly been adopted in Nepal. Prior to the 1950s, Nepal's traditional farming practices including oxen-pulled plows and hand cultivation were standard practice. Due to the nation's isolation and restricted access to advanced technologies, the usage of agricultural machinery was nearly unattainable. Huta Ram Baidhya, Nepal's first agricultural engineer, and Mr. Siddi Nath Regmi, Nepal's second agricultural engineer, laid the groundwork for agricultural mechanization in Nepal (Shrestha Shreemat, 2022). During their service dates various agricultural tools such as metal animal-drawn mould-board plough, disk harrow, thresher, pump set, tractor-trailer, wheel-barrow, hand hoes, etc. were manufactured at Agricultural Tools Factory (ATF). Later, during the 1970s and 1980s with the assistance of international organizations various mechanized agricultural machinery were imported and brought into application in farmers' fields.

Mechanized wheat cultivation is the practice of doing numerous tasks associated with growing wheat using contemporary machines and equipment. Mechanized farming techniques have a number of benefits over conventional farming practices, including timely sowing, increased productivity, and lower labor costs. Mechanized wheat farming includes various steps, such as preparing the land for sowing, fertilizing crop fields, irrigating, controlling weeds, and harvesting the crop. Utilizing various pieces of machinery including tractors, seed drills, cultivators, sprayers, and combines harvester, each of these phases can be mechanized. This study undertakes Super seeder (SS), rotavator and zero-till seed cum fertilizer drill (ZT) machinery which are used to sow the wheat in the field of DoAR Tarahara with standing stubbles after harvesting the paddy crop.

The Super Seeder machinery concurrently sow wheat seeds, mulch paddy waste, and distribute manure to lower the expense of removing the stubble. It is simple to use and handle, also a combination of a seed planter and a rotary tiller that requires little maintenance. The Super Seeder is a single-pass method that meets the needs of contemporary farming and avoids crop residue burning. It is a state-of-the-art agricultural instrument that helps farmers to sow wheat seeds more rapidly and precisely, increasing production. Similarly, rotavator, also known as a rotary tiller, is a tractor-driven secondary tillage tool that plows farmland with a number of blades attached on a rotating shaft to cut, pulverize, mix, and level the soil. In fewer passes through the field, they create an optimal seedbed for wheat or crop sowing. Also ZT, commonly referred to as no-till farming, is a way of cultivating crops without tillage procedures like harrowing or plowing the soil. Zero tillage's guiding principle is to cause the least amount of soil disturbance possible. This helps to maintain soil structure, minimize soil erosion, and keep soil moisture in check. These mechanized cultivation practices produce an increase in productivity and reduced the cost and time of sowing. Additionally, the use of these treatments reduces the burning of crop residue that has detrimental effects on both the environment and human health.

Various modern machinery has been introduced to the market in this mechanized era to make field work more productive, less time-consuming, and less expensive. Since Nepal's agricultural land is shrinking day by day causing the nation to experience food insecurity, where mechanization in wheat production operations has assumed a crucial role. A sense of importance toward mechanization in the agricultural industry has also been produced by the workforce scarcity for agricultural jobs. The desire for farm mechanization is a result of a shortage of agricultural workers and their rising daily wages. Additionally, youngsters returning from foreign industrialized nations are perceived as being more interested in and investing in their new careers in commercial agriculture, creating a significant need for mechanization in agriculture (Thapa Dhruba, 2021)

Mechanization in agriculture is essential for boosting crop production and productivity as well as the effectiveness of field labor. The use of various automated machinery during various stages of field operation helps to finish the work more quickly and affordably. Indirectly, it aids in managing the straw left over from paddy harvesting. In order to cultivate wheat, a variety of tools have been developed and made available to farmers, including the rotavator, ZT, SS, sprayer, reaper, thresher, and combine harvester. By using this equipment in farmers' fields, the labor scarcity issue and other farm-related issues are addressed, increasing overall field production and lowering cultivation costs. The use of special wheat sowing equipment, such as the SS, and ZT, makes it possible to plant wheat seeds among the standing paddy stubbles in the field, assisting farmers in resolving their straw burning issue. These techniques for sowing wheat help to increase the soil's biomass content, protecting the soil's microbial community and nutrient content. By enhancing and commercializing agriculture, mechanization also improves food security. The main purpose of this study is to comprehend the various factors that affect the yield produced when using different machinery, to conduct a comparative economic analysis of these machinery in the production of wheat, and to recommend to farmers the best machinery that produces a higher yield at a lower cost of production. According to Jha et al. in Bangladesh traditional farms produced 2.57 mt/ha less wheat than mechanized farms (2.65 mt/ha).

Another study on, “Zero till in wheat from the gender perspective in Nepal” by Sudha Sapkota et al. (January 2021) evaluates the implementation of different tillage practices in the farmer field of Sunsari district. This paper discusses the justifications for gender inclusion in the project and the development studies. A comparison of traditional practice and zero-till wheat production revealed that the producer can save about NRs. 4000/ha during cultivation practices, but that NRs. 9842/ha can be saved from a hectare of land when the product is harvested. As a result, the Sunsari district can profit from zero-till wheat. The producer was given more authority by the introduction of zero-till because of the higher income. Although the yield advantage of ZTW was not significantly greater than that of conventional till wheat (CTW), the additional benefit of almost 34% persisted enough for the farmers to choose the zero-tillage technology. Farmers estimated that they could reduce their seed requirements by 17% and their irrigation costs by 13%.

“Present status and prospect of appropriate mechanization for wheat and maize cultivation in Bangladesh" by Israil Hossain (August 2017) examine the planting cost, fuel saving between mechanized planting (zero till and strip till) and conventional methods. The study after 23 crops in the rotation of “wheat-mung bean-rice” with 30% crop residue retention showed that wheat, mung bean yields under strip till and no till planting were higher than conventional methods. The savings of planting cost for maize and wheat were found 77%and 44%, respectively. The net returns of maize and wheat cultivation are 1.3 times and 1.7 times compared to conventional manual planting methods. Strip till planters also avoid labor for seeding and earthing operation of maize as well as wheat seeding. There were significant planting cost differences of 4000 Tk/ha. and fuel savings differences of 66.8% between mechanized strip till planting and conventional manual method. The study also states that the fuel consumption by conventional method is 23.4 times higher than the mechanized strip till method of planting

Another “Assessment of seed cum fertilizer drill for wheat sowing after paddy harvesting” by R.P. Murumkar et al. (May 01 2023) conducted an investigation to evaluate the effectiveness of tractor-operated seed cum fertilizer drills for seeding wheat after paddy harvesting. With a seed rate of 100 kg/ha, it was discovered that the field's capacity, sowing depth, and yield were each 0.67 ha/h, 4 cm, and 12.10 q/ha, respectively, as opposed to 0.50 ha/h, no depth, and 6.13 q/ha seen when using the traditional broadcasting method. In comparison to broadcasting, the mechanized sowing method produced a 50% greater depth of sowing. (Gautam & Aulakh, 2022)

Similarly, “Impact of Sowing Technologies of Wheat Cultivation in Ferozepur, Punjab” by Anand Gautam and Gurjant Singh Aulak (May 11 2023) carried out a field experiment on the four different sowing methods (Broadcasting +Mulcher, PAU Happy Seeder, Super Seeder, Zero Drill) on different three locations on district of Ferozepur (Punjab) during 2021-22, and found out the utmost yield was obtained in PAU Happy Seeder (54.45 q/ha) sowing methods in comparison to other three sowing method (Broadcasting + Mulcher (51.85 q/ha), Super Seeder (49.15 q/ha) and Zero Drill (45.95 q/ha), also higher B: C ratio was obtained by PAU Happy Seeder. The study also reports that the continuous application of PAU Happy Seeder will have a positive outcome on fertilizer management as it provides a healthier option for management of crop residue in the rice-wheat cropping system. This study concluded that PAU Happy Seeder can play an essential character in retaining soil and ecological fitness in Punjab. (Ali et al., 2021)

II. METHODOLOGY

Directorate of Agricultural Research, Koshi Province, Tarahara, Sunsari under Nepal Agriculture Research Council is selected as the experimental field. Geographically the study area covers about 104 ha. and extends 26°42'09.2" North in Latitude and 87°16'34.7" East in Longitude. It is five kilometers north of Itahari Chowk lying on the eastern side of Dharan-Biratnagar highway. Tarahara has six command districts of Eastern Terai Region (ETR) of Nepal. It has a tropical zone with warm climatic conditions. It is located at an elevation of 136 meters above sea level. The soil texture of whole farm land is dominated by clay loam with sandy loam to loam varying with the distribution of land within the farm. The pH of the soil ranged 6.5-7.0 which indicates slight acidic to neutral status of the soil. (*Grain Moisture Meter*, n.d.)

In this study we mainly focus on the comparative economic and analysis of various treatments used in wheat cultivation such as super seeder, rotavator and zero-till seed cum fertilizer drill to compare the productivity and cost of production using these treatments. To carry out these studies following activities were performed in the selected three plots in the field of Directorate of Agricultural Research (DoAR).

Wheat calibration

Calibration is the process of altering and setting the equipment's numerous characteristics and parts to make sure they are functioning accurately and effectively. By lowering the chance of over- or under-applying inputs, calibration enables the machinery to run as efficiently as possible, improving crop yields, cutting down on waste and costs, and enhancing operator safety. Regular calibration of these agricultural implements helps to ensure that the crops are dropped properly at optimum depth and adequate row spacing is always maintained between the crops. The calibration of the treatments subjected in this study are described as below:

Calibration of Zero till seed cum fertilizer drill

The method of calibration of ZT that we adopted in the field 4 is described below:

1. First of all, the diameter of transport wheel (d) in meter is measured to calculate the circumference of wheel

   Circumference (C) = π *d

2. The effective width of the seed drill is then measured

   Effective width (W) = N*S

   Where, N = number of furrow opener

   S = Spacing between the opener

3. Calculate the area covered in one revolution of wheel

   Area covered in one revolution = C * W

4. Calculate the number of revolutions required to cover 1 ha. Area i.e. 10,000 m^2

   $R = \frac{10000}{C*W}$

5. Raise the seed drill, so that the wheel for N turns and collect the seed under each tube on paper bags or cloth and measure the weight (K) of collected seed.

   Calculate the seed weight of the number of revolutions required for one ha. area

   Seed rate = $\frac{R*K}{N}$ Kg/ha

Calibration of Super Seeder

First of all, fill the seed and fertilizer in the respective boxes. Set the indicator at desired seed and fertilizer rates. Mark a distance of 50 meters in the field Take the seed and fertilizer delivery pipes out from the boots and put delivery outlets of the pipes in the polyethene's bags and tight them using rubber rings. Run the machine and collect the seeds/fertilizers from each delivery pipe after a 50-meter run of the machine. The number of seed and fertilizer collected from each delivery pipe in a 50-meter run is then weighed in grams. Then we calculate the seed rate and fertilizer rate by the given formula:

1 ha. = 10,000 m^2
Width of planter = x (m)
Distance = 20 m

Weight of seed or fertilizer in pipes = y (kg)
Seed or fertilizer rate (kg/ acre) =$Weight\ of\ seed\ or\ fertilizer\ (Kg.)x\ Area/with\ planter\ acre$
If the seed or fertilizer rates are not as per the desired rates, then reset the indicators or the inclined plates, gears etc. in accordance to the desired rates and the whole process of field calibration is repeated as described above (Mulvaney & Devkota, 2020a)

Sowing of Wheat

The "BL4341" variety of wheat is sown in the field. The study's main goal is to compare the yields achieved by applying various treatments to each plot and conduct an economic analysis for each of these treatments. Three distinct fields with various treatments have been employed to sow the BL4341 variety of wheat. We assigned a number for each plot where wheat is sown using appropriate treatment.

Super Seeder and zero-till seed cum fertilizer drill and rotavator (Farmers practices) is operated directly into the field where there were standing stubbles of previously harvested paddy. A three-point connection system was used to attach these treatments to the tractor. The tractor's PTO shaft was connected to the machine's PTO shaft linkage, which powers the flail, after being hitched to the tractor. Seed and fertilizer begin to fall into the furrows and slits created by the furrow opener as the drive wheel drives the fertilizer and seed metering device. The flail begins to operate through the PTO shaft, and these revolving flails clean the debris that comes in front of the types.

For the comparative study of economic analysis of various treatments used for seed establishment in wheat cultivation, various data are collected from both the primary source as well as secondary sources such as research articles, journals and books related to research topics. Primary data was collected from the time of sowing of wheat crops in the field using various treatments till the harvesting of fully ripened wheat. The data for analysis were collected before and during treatment operation in the field i.e. before operation of treatments the area of field is measure and during operation the time taken by each treatment to complete sowing in respective field using particular treatment, calibration of super seeder and zero-till seed cum fertilizer drill implement, horsepower of tractor used to pull these treatments in field, rate of discharge of water during irrigation in the field, various plant parameters such as plant height, spike length, number of plant per tiller, grain weight per meter square, grain moisture number of grain per spike and plant population in 1m*1m area for 10 numbers of replication on each treatment. Also after fully ripening of wheat crop the yield data of each plot (i.e T1, T2, and T3) was also collected. The experimental area of each plots is T1 Super seeder, T2 farmers practice and T3 Zero till seed drill 6 katta. The seed rate of the super seeder and ZT at which it drops both the seed and fertilizer was set at 120 kg/ha. This rate was set only after the calibration of both of these machines.

The fertilizer doses supplied were at the rate of 100:60:60 kg NPK/ha. The full dose of phosphorous, potash and half dose of nitrogen were applied as basal dose during the time of land preparation while remaining half dose of nitrogen was top dressed. The source of phosphorous was Dia-ammonium phosphate (DAP) and that of potassium was muriate of potash and of nitrogen was DAP and urea.

III. RESULTS AND DISCUSSION

The Result and Discussion portion contains the findings from project site observation, measurement, computation, and comparison of various parameters of wheat crop.

Calibration of Super Seeder

The calibration procedure of Super Seeder is similar to that of Turbo Seeder. The calibration calculation is performed by obtaining following data:

Number of rows (N)	=	10
Spacing between two rows (S)	=	22 cm = 0.22 m
Width of sowing (B)	=	N*S = 10*0.22 = 2.42m
Length (L)	=	13.19 m
Area (A)	=	L*B = 13.19*2.42 = 31.91m^2 = 0.00319 ha
Weight of seed or fertilizer sowed	=	0.383 kg
Rate of seed or fertilizer calibration	=	$Weight\ of\ seed\ or\ fertilizer\ sowed/Area$ = 120 kg/ha

Calibration of Zero till Seed Cum-Fertilizer Drill

Calibration of Zero-Till is done by measuring the following parameters of the machine.
Calculation

1. Diameter of transport wheel (d) = 42 cm = 0.42 m
2. Circumference (C) = π *d = π * 0.42 = 1.35 m
3. Effective width (W) = N*S = 9*0.2 = 1.8 m
4. Area covered in one revolution = C * W = 1.35*1.8 = 2.43 m
5. Number of revolutions required to cover 1 ha.
   R = $\frac{10000}{C*W}$ = 10000/2.43 = 4115
6. Weight (K) of collected seed in plastics for 10 revolution of wheel= 0.29 kg
7. Seed rate = $\frac{R*K}{N}$ Kg/ha = 120 Kg/ha

Plant Height in cm

The average height of the plant from all 10 replications was measured in each field plot before harvesting. The average height of the plant on the plot using a super seeder was found to be 95.9 cm, 95.4 cm on the plot with the rotavator (farmer’s practice) used, and 97.7 cm on the plot with the ZT used plot. The average height of the plant of each 10 samples in replication is given by the table in 1.

Table 1: Average Plant Height in cm

Treatment used	Average plant height (cm)
Super seeder	95.9
Farmers practices	95.4
Zero-till seed cum fertilizer drill	97.7

From the above treatment we can see that the plant height of the wheat crop was found to be high in the ZT used field plot in comparison to farmer's practice and super seeder used plot. This can also be presented in graph as below:

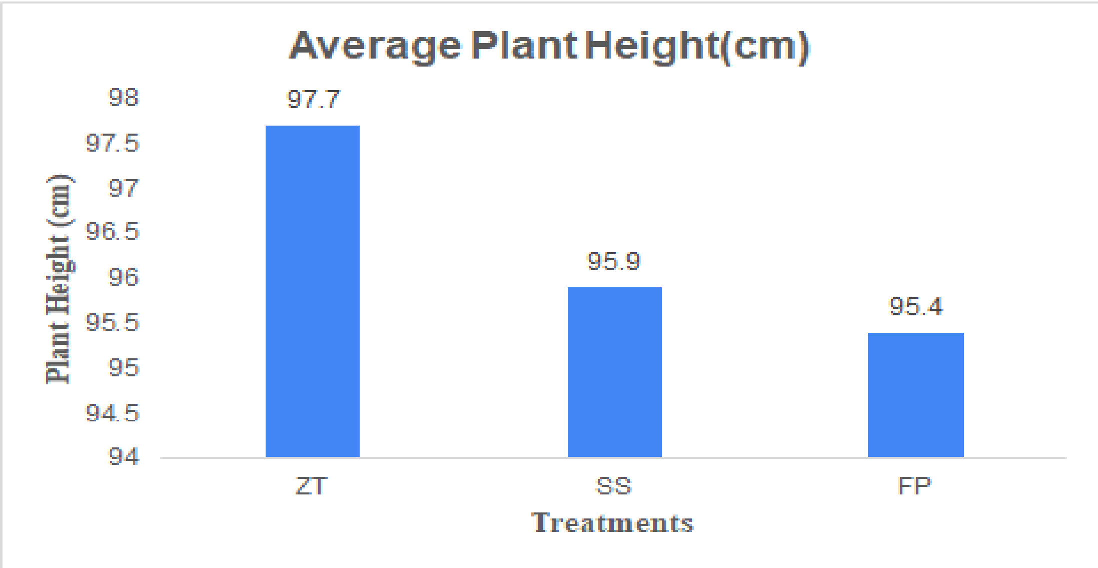

Figure 1: Average plant Height (cm).

The plant height of ZT is higher in comparison to other two treatments, which may be because of early germination of seed in the field where ZT is used for seed establishment. Also this field has higher capacity to retain moisture due to less soil manipulation or no-till.

Spike length in cm

In this study we assess the spike length of the wheat crop using a measuring scale. With each plot undergoing a different treatment, 10 spike length samples were collected. The zero-till seed cum fertilizer drill produced the highest average spike length of 10.2 cm, which was followed by 9.8 cm from farmer's practice and 9.7 cm from super seeders. The sample data for each treatment are shown in table 2.

Table 2: Average Spike Length in cm

Treatment	Average Spike Length (cm)
Super seeder	9.7
Farmers practices	9.8
Zero-till seed cum fertilizer drill	10.2

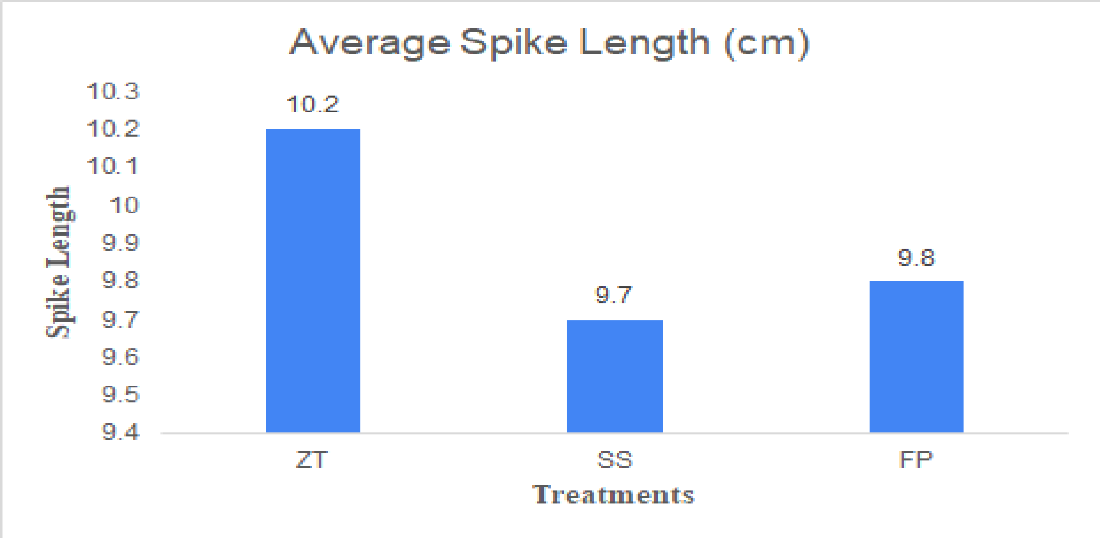

Figure 2: Average spike Length (cm)

The spike length in ZT practice is longer than in SS and FP, as shown in the above-mentioned graph and table. This difference may be attributable to timely sowing, suitable fertilization, and efficient weed control. Additionally, efficient control of pests and diseases that target the spike or inflorescence can help prevent damage and ensure long spike length.

Average of grain per Spike

The number of grains in each spike was determined by counting each individual grain of wheat. From each field plot, 10 samples of grain were selected for this investigation, and the grains were manually counted. The field with the use of a zero-till seed cum fertilizer drill had the highest average number of grains per spike, 40, and was followed by a super seeder plot's 35 and a farmer's practice plot's 34.

Table 3: Average Grain per spike in number

Treatment	Average grain per spike in number
Super seeder	35
Farmers practices	34
Zero-till seed cum fertilizer drill	40

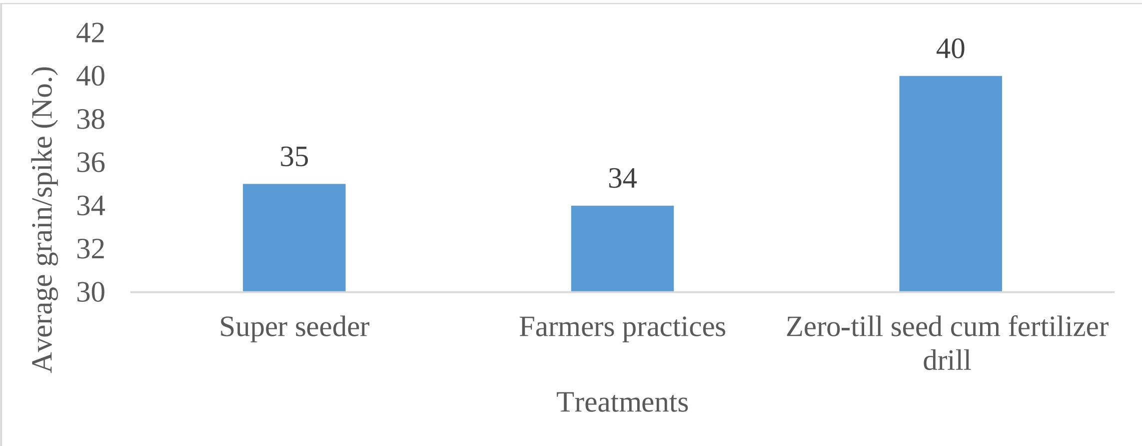

Figure 3: Average Grain per spike

As evidenced by the table and graph above, there are more grains per spike in FP. The optimal plant density in FP enables each plant to have adequate access to sunlight, nutrients, and water, improving grain development and increasing the amount of grains per spike.

Number of tillers per plant

A tiller is a sprout that emerges from the plant's base and bears leaves, stalks, and occasionally flowers. A plant's prospective output may be significantly influenced by the quantity of tillers it generates. In this study the number of tillers per plant is counted manually and the obtained data was recorded. The average number of tillers per plant data is as given in table 4 below:

Table 4: Average Number of tillers hill.

Treatment	**Average number of tillers per plant**
Super Seeder	9
Farmers Practice	8
Zero-Till Seed cum Fertilizer Drill	9

The data of all replication on the number of tillers per plant of respective treatment is given in figure.

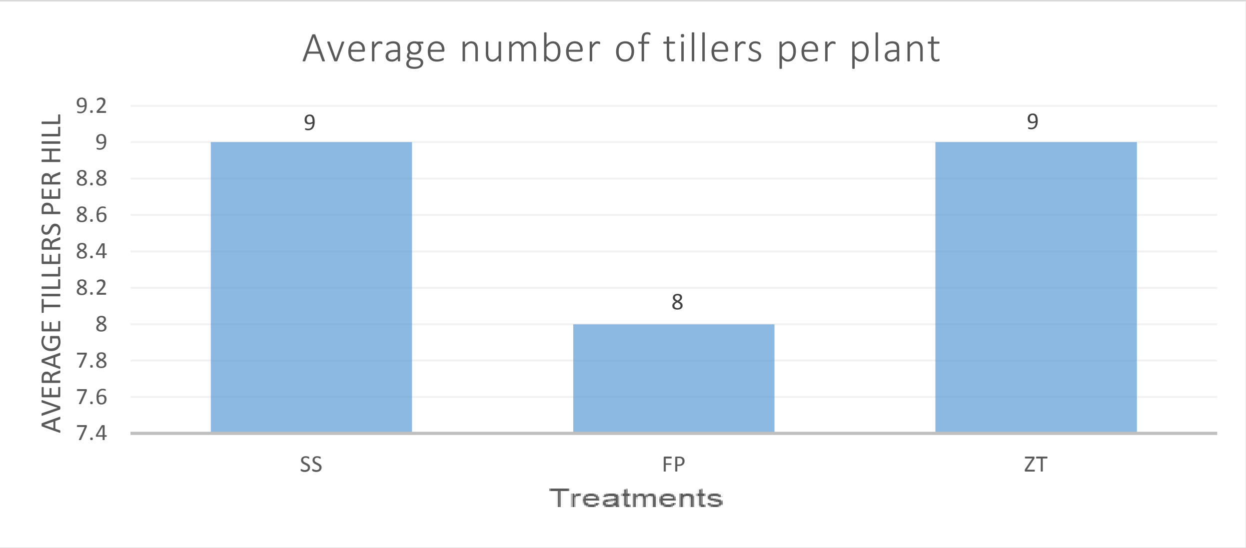

Figure 4: Average number of tillers per hill

Number of plant population per 1 m^2

The number of plants that retained inside the 1m*1m metal frame is then counted manually. The average plant population in each plot was found to be 331.6, 310 and 291.3 respectively in plot-1, 2, and 3. The average number of plants in the 1mx1m area of the super seeder plot was found more than the other two Plot. Data on the number of plants per square meter of each 10 replications are given in table 5.

Table 5: Total Plant Population per m^2.

Plot	**Treatments**	**Average Plant population per m^2 in number**
1	Super Seeder	332
2	Rotavator/ farmer practices	310
3	Zero-Till seed cum fertilizer drill	291

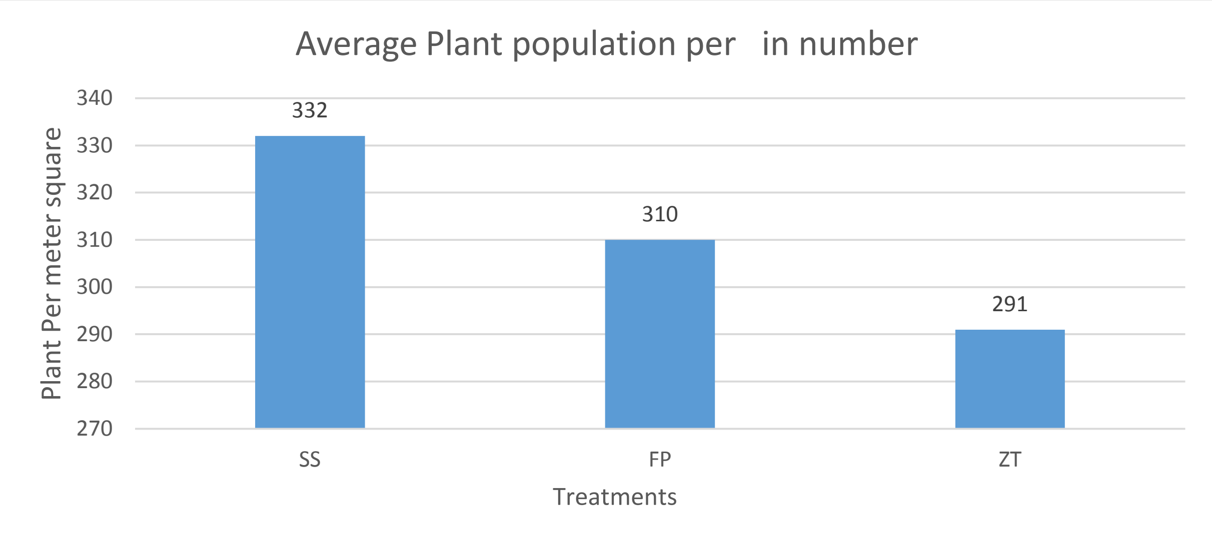

Figure 5: Average plant population per meter square

Thousand grain weight in kg

The thousand grain weight is calculated by counting thousand wheat grain and measuring its weight and the obtained weight is as follows:

Table 6: Thousand grain weight.

Treatment	**Thousand grain weight (kg)**
Super Seeder	0.02978
Farmers Practice (check)	0.02904
Zero-Till Seed cum Fertilizer Drill	0.02132

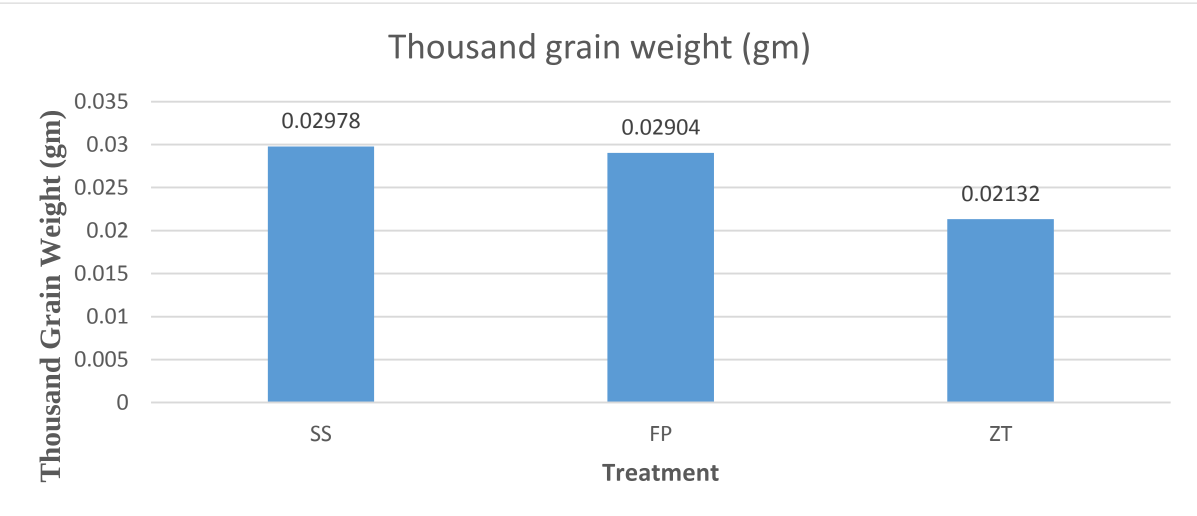

Figure 6: Thousand Grain weight

From above table 6 and graph 6 the thousand grain weight from super seeder (0.02978 kg) is found greater and thus we can say that the flour quality of wheat from this method will be of higher quality than the other two methods.

Wheat yield in 1 m2 area

For the yield calculation from selected $1m^2$area, a metal frame of 1m*1m was randomly placed at ten different points on each plot and the wheat crop that retained into the frame was manually harvested and then threshed. The ten replication for each treatment were given respective name such as for first plot with Super Seeder replication is denoted as SR1, SR2, SR3, SR4, SR5,......,SR10 for Rotavator employed plot replication is denoted as RR1, RR2, RR3, RR4,....... ,RR10 similarly for Zero-Till field replication is denoted as ZR1, ZR2, ZR3, ZR4,........... ,ZR10. The average yield from randomly selected replication in all three plots was found to be 248.44 gm. (ZT), 342.69 gm. (SS), and 306.18 gm. (FP) respectively. From the above data the average yield from the Super Seeder used field was found higher in comparison to other two treatments. The sample yield of all 10 replications of all three treatments is given in experiment.

Total yield of entire field

After measuring the average yield from 1m*1m using respective treatment the total yield of the entire plot and yield per hectare is determined and presented as shown in table 1.

Table 7: Total yield of entire field

Plot	**Treatment used**	**Average yield in $1m^2$ area (Kg) of the Exp.**	**Yield in 1 ha. Area (Kg/ha)**
1	Super Seeder	0.34269	3426.9
2	Farmer Practice (Check)	0.30618	3061.8
3	Zero-Till Seed cum Fertilizer Drill	0.24844	2484.4

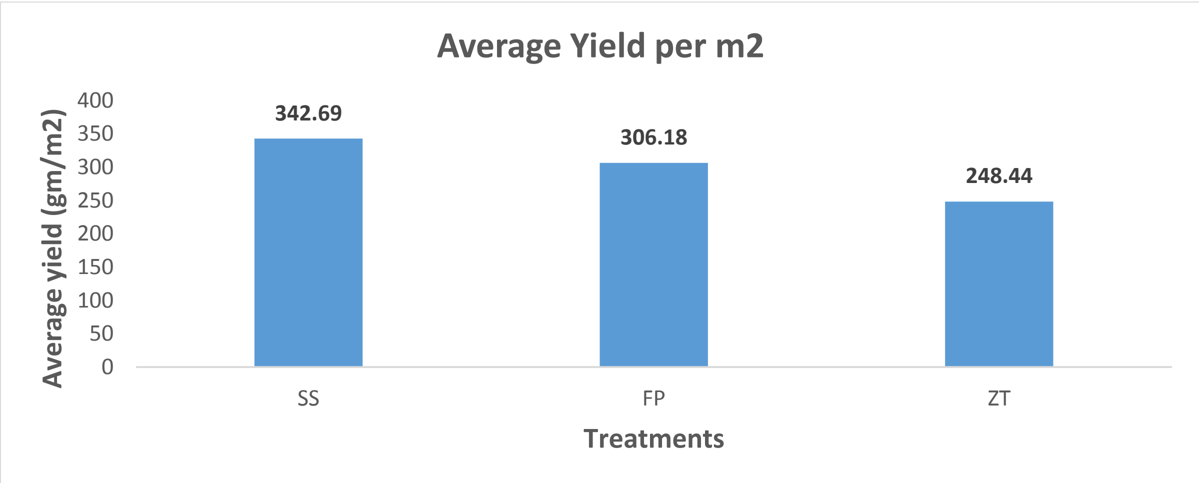

Figure 7: Average Yield per m^2

The average wheat production in Sunsari district is 3250 kg per hectare(*Wheat Seed Production Techniques Manual*, n.d.). In the comparison of the data from table 4.1 with the yield data of sunsari district, the production of wheat was found to be higher from super seeder application. The yield is found higher in the Super Seeder method which is 3426.9 kg/ha followed by farmer's practice (3061.8 kg/ha) and zero-till seed cum fertilizer drill (2484.4 kg/ha). The lower in the yield from plot 2, and 3 in comparison to plot 1 with super seeder method may be due to various factors such as non-uniform seed rate of treatments, soil moisture, soil texture, level of ground water table in the study area, method of sampling, over or under irrigation etc.

Straw yield

After the grain was threshed only straw remains, the average amount of straw yield from each treatment was found to be 0.33883 kg/m^2, 0.31126 kg/m^2 and 0.25695 kg/m^2 respectively on each plot where super seeder, farmer's practice and zero-till seed cum fertilizer drill was employed for wheat sowing. The amount of straw yield per hectare is as shown in table 2.

Table 8: Straw yield per ha.

Plot	Treatment	Average Straw yield (Kg per m^2)	Straw yield per hectare (Kg/ha)
2	Super Seeder	0.33883	3388.3
3	Farmers Practices	0.31126	3112.6
4	Zero-Till Seed cum Fertilizer Drill	0.25695	2569.5

Moisture Content of wheat grain

When storing grains after harvest, grain moisture content is an important factor to take into account. The ideal moisture content needed to store wheat grain is 12 %(Mulvaney & Devkota, 2020b). In order to get the appropriate moisture for storage over a longer length of time, the drying process reduces the moisture content of grains, which is typically high during harvest time. In this study, we found moisture contents range in between 12% to 13.42%. The average moisture content of all three treatments was found to be 13.42%, 12.81% and 12.56%, respectively, in the plot where wheat was sown using a super seeder, rotavator or farmers practices, and zero-till seed cum fertilizer drill.

Table 9: Moisture Content of grain.

Treatments used	Average Moisture content (%)
Super Seeder	13.42
Farmers Practices	12.81
Zero-till seed cum fertilizer drill	12.56

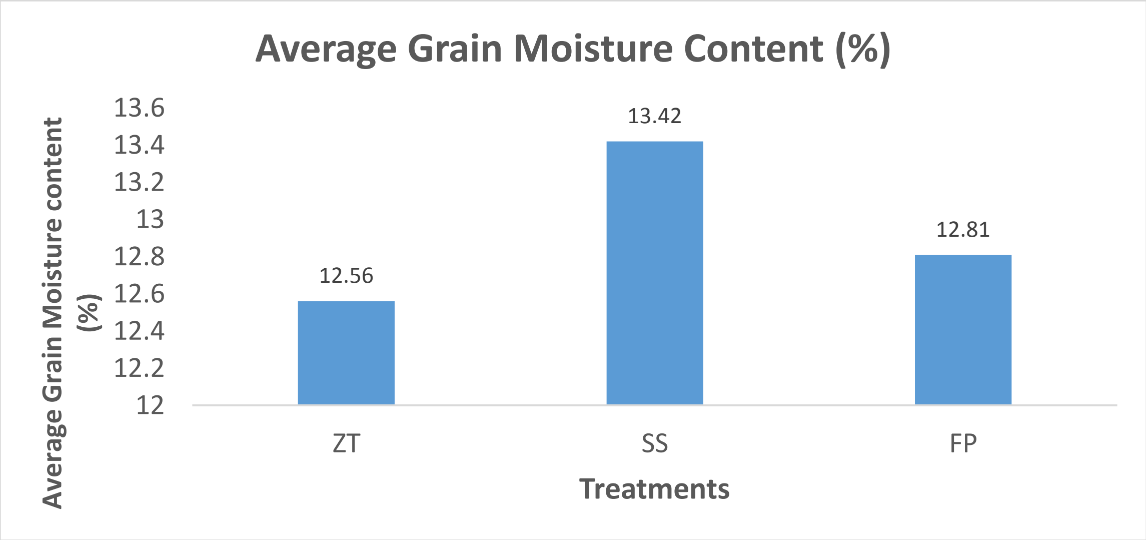

Figure 9: Average Moisture Content of grain

From the above table and graph we can say that the moisture content of wheat crop is higher from the plot where super seeder is used for wheat sowing followed by farmers practice and ZT. As the field soil has greater capacity to hold moisture and water in the field where super seeder was employed, thus wheat grain has a higher moisture content. As a result, the crop plant receives the necessary amount of hydration throughout the crop time. Sample data on moisture content of grain of each replication is given in figure 9.

Straw to Grain Ratio

The amount of straw to grain in wheat is greatly influenced by the wheat variety, the environment, and management techniques. In general, there should be 1.2 to 1.5 tonnes (1200 to 1500 kg) of straw produced for every tone (1000 kg) of grain produced in a wheat crop. This ratio is known as the straw-to-grain ratio. While crops with a low straw-to-grain ratio might be better suited for grain production alone, whereas those with a high straw-to-grain ratio can provide more crop residue for soil conservation, animal feed, or bio-energy production. The straw to grain ratio is calculated in this study by dividing the total straw weight by the grain weight.

Table 10: Straw-to-grain ratio.

Plot	Treatment	Total grain yield (Kg/ha)	Total straw yield (Kg/ha)	Straw to grain ratio
1	Super seeder	3426.9	3388.3	0.98
2	Farmers practices	3061.8	3112.6	1.02
3	Zero-Till seed cum fertilizer drill	2484.4	2569.5	1.03

In the above table and graph we can see that the straw to grain ratio of FP and ZT is found greater than 1 which indicates that the obtained straw and grain are equal in quantity. Whereas in case of super seeder the straw to grain ratio is less than 1 which indicates that either the straw or grain yield is higher and from the above table we can see that the grain yield is higher than the straw yield.

Adjusted yield

Adjusted yield describes crop yield that has been modified to take into account variables like weather, disease outbreaks, and other elements that can have an impact on production. The process of calculating adjusted yield entails starting with the actual yield and making various adjustments to it. A more accurate picture of the true productivity of a crop or farm can be obtained by accounting for several elements in the yield. An essential part of handling and storing grains is bringing their moisture levels up to par. It enhances the wheat crop's efficiency, marketability, storability, and ability to maintain quality. The adjusted yield is calculated using the formula below (Mulvaney & Devkota, 2020c)

Table 11: Adjusted yield.

Treatment	Total yield (Kg/ha)	Harvested moisture (%)	Adjusted yield at 12 % MC(Kg/ha)	Adjusted yield at 14% MC (Kg/ha)
Super Seeder	3426.9	13.42	3371.60	3450.01
Farmers Practices	3061.8	12.81	3033.62	3104.17
Zero-Till Seed cum Fertilizer Drill	2484.4	12.56	2468.59	2525.99

From the above table, the adjusted yield (Kg/ha) is higher in super seeder followed by farmers practice and zero-till seed cum fertilizer drill

Gross Margin

In this study, the gross margin of each treatment was calculated by deducting the total variable cost of production with the total revenue from the field.(Pravesh Yadav et al., 2023) We measured variable costs under different heads such as:

Table 12: Gross Margin

Particulars	Super Seeder	Zero-Till seed cum fertilizer drill	Farmers practice (Check)
Revenue:			
Grain yield at 14% MC (Kg/ha)	3450.01	2525.99	3104.17
Straw yield (kg/ha)	3388.3	2569.5	3112.6
Return from Grain (Rs/ha)	120750.35	88409.65	108645.95
Return from straw (Rs/ha)	10164.9	7708.5	9337.8
Total Revenue:	**130915.25**	**96118.15**	**117983.75**
Variable Cost:			
Sowing machine hire cost (Rs/ha) + Operator charge	7602	4077	13500
Labor for seed and fertilizer Sowing (Rs/ha)	577	577	1731
Land preparation cost	**8179**	**4654**	**15231**
Seed Cost (Rs/ha)	9000	9000	9000
Fertilizers Cost (Rs/ha)			
DAP (Rs/ha)	3967.438	3967.438	3967.438
Urea (Rs/ha)	929	929	929
Potash (Rs/ha)	1451.193	1451.193	1451.193
Total Fertilizers Cost (Rs/ha)	**6347.63**	**6347.63**	**6347.63**
Herbicide cost (Rs/ha)			
Pendymethyline	2520	2520	2520
2-4-D	1170	1170	1170
Glyphosate	0	2700	0
Total herbicide cost (Rs/ha)	**3690**	**6390**	**3690**
Labor cost for fertilizer application Rs/ha)	1154	1154	1154

Labor cost for herbicide application (Rs/ha)	1154	1154	1154
Labor for irrigation Cost (Rs/ha)	577	577	577
Total labor cost	**2885**	**2885**	**2885**
Irrigation Tariff (Rs/ha)	**2367**	**2367**	**2367**
Harvesting machine hire cost (Rs/ha)	11000	11000	11000
Total variable cost	**43468.63**	**42643.63**	**50520.63**
Gross margin (Revenue-Variable cost)	**87446.62**	**53474.52**	**67463.12**
Gross Margin Rank	**I**	**III**	**II**

Price rate:

Item	Rate
Farm gate price of wheat grain (Rs/kg)	35.0
Farm gate price of straw (Rs/kg)	3.00
Labor Rate/day Skilled Labor Unskilled Labor	 750.00 577.00
Seed price (Rs/Kg)	75
DAP price (Rs/Kg)	44.7
Urea price (Rs/Kg)	15.7
Potash price (Rs/Kg)	32.7

From the above calculation it is found that the farmer's practice approach is an economically beneficial method for sowing the wheat crop as the net benefit of this method is higher as compared to other two methods.

Benefit Cost Ratio (BCR)

After calculating the net benefits of each method, the BCR value is also calculated by dividing the net benefit value by the total cost of production. The BCR value of all three method is as shown in table:

Table 13: Benefit Cost Ratio (BCR).

Treatment	Gross-Benefit Value	Total cost of Production	BCR Value
Super Seeder	87446.62	43468.63	2.01

Zero-Till Seed cum Fertilizer Drill	53474.52	42643.63	1.25
Farmers Practices (check)	67463.12	50520.65	1.34

The BCR value of Super Seeder and Zero-Till Seed cum Fertilizer Drill and farmer's practice is greater than 1 which indicates that these methods are beneficial and outweigh its costs, while a BCR value of Farmers Practice is less than SS. Therefore, the implementation of Super Seeder is found attractive in terms of financial perspective. Furthermore, super seeder is more beneficial than FP.

IV. CONCLUSION

When compared to Farmer's Practice, Zero-Till Seed Cum Fertilizer Drill, and the Super Seeder revealed a definite advantage. From the above-mentioned result, it can be shown that the yield of wheat per hectare using the Super Seeder is 11.14% higher than the farmer's practice, whereas the yield using the Zero-Till Seed cum Fertilizer Drill method is 18.63% lower than the farmer’s practice. Crop plants grown using a Super Seeder had better averages for tillers per plant, grain weight per thousand, grains per spike, and plants per square meter. The plant height is found higher in Zero-Till Seed cum Fertilizer Drill used field crop. Additionally, Super Seeder reduced the cost of production by Rs. 7052.02 per hectare, or 13.95%, compared to Farmer's Practice. Similar to this, the cost of production in the Zero-Till Seed cum Fertilizer Drill technique increased by Rs. 1141 per hectare, which was 2.83% more than the Farmers Practice Method. In the production of wheat, the Super Seeder was shown to be more profitable than Farmer's Practice, as evidenced by the Super Seeder's Benefit-Cost Ratio of 2.44. The Benefit-Cost Ratio for Zero-Till Seed cum Fertilizer Drill was found to be 1.39, which is greater than Farmer's Practice (0.2), indicating that it is more profitable to use the Zero-Till Seed cum Fertilizer Drill than the Farmer's Practice method. As a result, it can be said that the establishment of wheat using a Super Seeder and a Zero-Till Seed cum Fertilizer Drill is more profitable and effective than utilizing the Farmer's Practice approach. When comparing the Benefit-Cost Ratio of each method, Zero-Till Seed cum Fertilizer Drill is more profitable than Farmer's Practice.

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