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RESEARCH ARTICLE

EFFECT OF TILLAGE OPTION ON WHEAT CULTIVATION

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ABSTRACT

A study was conducted to know the variation in the effects of various tillage methods on growth and growth components and the cost of production of wheat cultivation. The methods of tillage studied were zero tillage with residue management and without residue management, bed planting and compared with conventional practice. Number of tiller plant^{-1} was 4.4, 3.36, 2.44 and 1.3 and plant height was 44.15, 43.42, 39.8 and 36.3cm in zero tillage with mulching, zero tillage without mulching, bed and conventional method respectively. Intensity of weed growth is higher in bed than conventional method and lower in zero tillage with mulching. Panicle length was 7.3 in conventional method and nearly same and above 9.5 in the other methods. Economic yield was 3.312 t ha^{-1}, 3.127 t ha^{-1}, 3.097 t ha^{-1} and 2.59 t ha^{-1} and biological yield was 5.246 t ha^{-1}, 4.940 t ha^{-1}, 4.128 t ha^{-1} and 4.501 t ha^{-1} and harvest index was 0.631, 0.633, 0.750 and 0.575 in the method of zero tillage without mulching, zero tillage with mulching, bed and conventional respectively. Cultivation cost was 31751 Tk. ha^{-1}, 28789 TK. ha^{-1}, 29258 Tk. ha^{-1} and 32817 Tk. ha^{-1} and benefit cost ratio was 2.34, 2.76, 2.57 and 1.89 in the method of bed, zero tillage without mulching, zero tillage with mulching, and conventional respectively. The cost saved by the method of bed, zero tillage without mulching and zero tillage with mulching were 3.4%, 14% and 12.2% respectively compared with conventional method but the highest return obtained from zero tillage without mulching method. So the better wheat cultivation method is zero tillage method without residue management, followed by zero tillage with residue management method, bed planting method and the conventional method of cultivation.

INTRODUCTION

Conservation agriculture (CA) techniques have been developed to reduce the negative environmental effects of agriculture such as soil degradation of physical properties and soil erosion, leading to decreased productivity. CA techniques involve minimum disturbance of soil, residues retention, and optimal rotation or association of crops (Smart and Bradford, 1999). In Australia, Conservation tillage (CT) is the reduction of tillage operations but not necessarily the preservation stubble or residues, due to the difficulty of establishing crops in high-stubble loads given slow residue breakdown during dry summers (Lyon *et al*. 2004). In California, CT is considered to be the reduction in equipment passes in the field by 40 percent or a crop residue cover of 30 percent (Mitchell *et al*. 2007). Well-documented benefits of CT production include reduced soil loss due to water and wind erosion; increased water infiltration and soil water storage; reduced labor, fuel and equipment use; improved soil tilth; increased cropping intensity; increased soil organic matter; and improved water and air quality (McLaughlin and Mineau 1995).

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In zero tillage, soil preparation is minimal, only enough to bury the seed. Zero tillage has been practiced since the beginning of agriculture until the invention of animal-drawn ploughs. However, zero tillage with scientific bases, as an alternative to conventional tillage, began in the 1940s with the discovery of hormonal herbicides that allow farmers to control weeds without resorting to cultivators or hoes. Nowadays, there are approximately 90 million hectares worldwide under zero tillage (Derpsch, 2003). Zero tillage affects water availability to plants, essentially through soil water capture and root uptake capacity (Gajri *et al*., 1994; Ojeniyi, 1986). Zero tillage has also been reported to increase total nitrogen and microbial biomass in various soils (McCarty *et al*., 1995). Moreover, zero tillage reduces the number of field operations reducing input costs for labor, fuel, tractors, and other equipment (Raper *et al*., 1994). Zero tillage generally results in greater economic returns, compared with conventional tillage system, due to both greater yields in dry years and smaller production costs in all years (Smart and Bradford, 1999). Bed planting systems have been used in cultivation for centuries (Ghane *et al*., 2009). The origin of raised-bed cultivation has traditionally been associated with water management issues, either by providing opportunities to reduce the impact of excess water in rainfed conditions, or to more efficiently

deliver irrigation water in high production irrigated systems (Sayre, 2004). Over the past 20 years, farmers in the irrigated areas in the northwest state of Sonora in Mexico have adopted an innovative system by which wheat is planted in defined rows on top of beds with irrigation supplied in furrows between the beds. Among different planting methods used for wheat cultivation, bed planting is a new technique in farming system of Turkey. Systems the same as or similar to the ridged bed in Turkey are also practiced in many other areas for different crops such as cotton, maize, soybean etc. Many benefits from the bed planting have been reported (Kumar *et al*., 2007; Holland *et al*., 2007).

Likewise, there are some benefits of this planting system such as low seed rate, decrease of field traffic, better irrigation management facilities, reduce of crop lodging and herbicide dependence, the control of rot diseases, better usage of chemical application machines, and better control of excess water in heavy soil condition (Sayre and Ramos, 1997). Wheat (*Triticum aestivum* L.) is one of the world's third most important cereal crops (the other two are maize and rice) and it has the widest distribution of any cereal. The crop is primarily grown for its grain, which is consumed as human food. It is the first important cereal crop of Turkey and now accounts for about 75% of the total cereal production with coverage of 11.9 million hectares (Anonymous, 2008). In Bangladesh cultivable land is decreasing day by day. On the other hand demand for food is increasing with the increasing of population. Land productivity is hampering and ground water level is lowering due to conventional practices. Soil physical and chemical properties and environment is seriously decreasing with excessive machine operations. Conservation technologies are the positive solution of these problems due to have their relative advantages of minimum machine operation, low cost of production, better yield, low irrigation requirement, improve soil productivity, increase infiltration rate, save turnaround time over traditional practices.

MATERIALS AND METHODS

In this study two planters were used for seeding wheat seed. One is Zero Till Drill used in zero tillage and the other is Versatile Multi-crop Planter (VMP) used for bed planting.

Zero till drill

By a power tiller operated zero till drill a maximum of 4-row can be planted at a time. Row spacing can be varied based on the agronomic requirement of crop. Fertilizer can be applied simultaneously with seed. Two kinds of fluted wheel type metering device can be used, one for regular shaped seed and the other for irregular shaped seed. For present study metering device was used for regular shaped seed.

Versatile Multi-crop Planter (VMP)

This is the improved version of minimum tillage planter that can be used for multi-crop seeding with Seed and fertilizer application simultaneously in line by Single pass shallow tillage, Strip tillage. Bed planting also can be accomplished by this machine

Experimental site

The research work was carried out at the Agronomy Field, Bangladesh Agricultural University, Mymensingh, during November 2009 to March 2010. Geographically the field is located at 24°75'N latitude and 90°50'E longitude at the elevation of 18 m above the sea level (Khan, 1997). The topography of the field was medium high belonging to the Sonatola soil series of grey floodplain soil under the Agro-ecological Zone-9 (AEZ-9) named Old Brahmaputra Floodplain (FAO, 1988). The soil was silty loam and well drained.

Climate and weather

The maximum and minimum temperatures during the growing season of the crop were 31.95°C and 11.70°C, respectively. The climate of the location is characterized by heavy precipitation during April to October (Biswas, 1987).

Treatments of the experiment

The experiment comprised three methods of tillage viz. conventional, zero and bed planting.

Experimental design

The experiment was conducted in one factor with 3 replications. The field was divided into three blocks of size 40m×16m for each method of planting. Each block was divided into three for replications.

Planting Material

The variety of wheat used for the study was Satabdi. The seeds of the variety were collected from the Wheat Research Centre, Dinajpur, Bangadesh.

Land preparation

For zero tillage land was prepared only applying Isopropile salt of glycophosphate (Round up) herbicide before 24 hours of planting or sowing. For bed planting land preparation is not required. In conventional system land preparation is a precondition for cultivation of wheat. Land was prepared by two ploughing for wheat cultivation.

Seed and Fertilizer Calibration

The planter was calibrated for seed and fertilizer and the rate was determined through calculation by using the following equation (Michael and Ojah, 1978).

$$\text{Equation } S_d = \frac{10W_s}{A_m}$$

Where, S_d= Seed rate (kg/ha), W_s= Total weight of seed (gm), A_m= Measured experimental area, m^2

The standard seed rate in zero tillage for wheat is 120 kg/ha and the standard fertilizer rate in zero tillage for wheat are 180 kg/ha.

Seed Sowing

In zero tillage system seed and fertilizer was applied at a time in the field of untilled soil through crop residue. The zero tillage drill was operated along the length of the rectangular field. Straight alternation pattern was used for sowing. For proper seed placement the speed of machine was controlled at 2.5 km hr^{-1}. In conventional system, land was ploughed by power tiller 3 passes followed by 2 laddering. Seed was broadcasted by manually. The seed rate in conventional system is 150 kg ha^{-1}. Seed rate for zero tillage was 120 kg ha^{-1}.

Fertilizer application

Fertilizer was applied at a same rate in all plots. The rate of application of DAP is 130 kg ha^{-1} during seeding operation and urea was 75 kg ha^{-1} (after 18 days of sowing).

Weed control

Isopropyl salt of glycophosphate (Round up) herbicide was used to control weed in all tillage systems before planting or sowing. Weed was counted from 1 m^2 plot in all replications. Weeding was done in all plots.

Irrigation application

There was no need of irrigation in the field due to presence of sufficient moisture in the field.

Harvesting and threshing

Crop sample was collected and threshed by manually from 1 m^2 of each replication. Then the remaining crop was harvested by reaper and threshed by power thresher and also winnowing was done by power winnower.

Field performance

Field capacity and field efficiency were calculated using the following formulae:

Effective field capacity, $$EFC = \frac{A}{T}$$

Where, EFC= Effective field capacity (ha hr^{-1}), T= Total time for the operation (hr) and A=Area coverage (ha)

Theoretical field capacity, $$TFC = \frac{WS}{10}$$

Where, TFC = Theoretical field capacity (ha hr^{-1}), S = Rated forward speed for machine (km hr^{-1}) and W = Rated width of the machine (m)

Working speed, $$S = 3.6 \times \frac{D}{T}$$

Where, S = Speed (km/hr), D = Distance of travel (10m), T = Time taken to travel 10 m (sec)

Field efficiency, $$F.E. = \frac{EFC}{TFC} \times 100$$

Where, F.E. =Field efficiency (%), EFC= Effective field capacity (ha hr^{-1}), TFC=Theoretical field capacity (ha hr^{-1})

Fuel consumption was calculated by using the following formula $F = F_t/T$

Where,

F= Fuel consumption rate (lit hr^{-1}), F_t= Fuel used during operation (lit), T= Total time needed for operation (hr)

Crop observation and data collection

The crop was observed regularly for weed, disease, insect and also for rat attack and the following characters were studied.

Growth parameters

Plant height (cm), Tiller $plant^{-1}$, Panicle length (cm)

Yield and yield contributing characters

100 seed weight (gm), Straw yield (t ha^{-1}), Biological yield (t ha^{-1}), Economic yield (crop yield, t ha^{-1}), and Harvest index (HI). HI was calculated at final harvest by following formula stated below

$$HI = \frac{Economic\,yield}{Biological\,yield} \times 100$$

Cost analysis

Cost analysis includes cost of machine operation and cost of cultivation.

Cost of machine operation (ploughing / planting)

The cost of operation the zero till drill was computed using the following equations involving the fixed and variable cost items. The total cost per year for the zero till drill can be expressed (Hunt, 1995).

$$AC = \frac{FC\,\%\,P}{100} + \frac{cA}{Swe}[(R\&M)P + O + L + F + T]$$

Fixed cost was determined by using the capital consumption method. Capital Consumption (CC) was expressed by the following equation

FC= (P-S) CRF + SI

$$CRF = \frac{i(1+i)^1}{(1+i)^1 - 1}$$

Total cost of production

Total cost of production was calculated for different tillage methods and compared among them.

RESULTS AND DISCUSSION

The field performances of zero till drill for zero tillage seeding and Versatile Multi-crop Planter (VMP) for bed planting of wheat seed were shown in Table 1. Initial soil moisture contents on dry basis were 44.3%, 40.0% and 42.6% for the plot of conventional, zero tillage and bed planting method respectively. Initial bulk densities of soil were 1.13, 1.19 and 1.17 g cm^{-3} in the plot of conventional, zero tillage and bed planting method respectively. Effective filed capacity of the zero tillage planters was 0.15 ha hr^{-1}. Field efficiency was 67%, 75%, and 70% for the conventional, zero, and bed system respectively.

Table 1. Planter's operational performance

S.No.	Operation	Zero tillage	Bed	Conventional
01	Speed of operation (km hr^{-1})	2.5	2.5	5.0
02	Theoretical field capacity (ha hr^{-1})	0.2	0.2	0.4
03	Effective field capacity (ha hr^{-1})	0.15	0.14	0.27
04	Field efficiency (%)	75	70	67
05	Fuel consumption (lit hr^{-1})	1.64	1.74	1.5 (one pass)
06	Fuel consumption (lit ha^{-1})	11.8	12.4	26.5 (Two pass)
07	Soil moisture content on dry basis (%)	40.0	42.6	44.3

Emergence rate

Effect of tillage option on the emergence of wheat seedlings has shown in the Figure 1.

Seedlings were started to emerge at 4 days after sowing (DAS) at the plots of conventional, zero tillage (without mulching) and bed planting and at 5 DAS at zero tillage (with mulching) plot.

Performance of emergence was found better in conventional method and followed by zero tillage (without residue management), zero tillage (with residue management) and then bed planting. After 13 DAS number of plant emerged was found constant. Number of seedling emerged was higher in conventional method may due to close contact of seed and soil. In the plot of zero tillage with residue management emergence was affected due to moisture stress as because initial soil moisture content was high during planting. Also sunlight and evaporation was hampered by the mulching materials. In the bed method emergence was affected by the compaction of moist soil with pressing roller. Latif *et al.* (2008) also reported that the weight of soil above the seed hindered the germination of wheat seed and seedlings to emerge. This weight was more detrimental, when the plank moved over it causing more compaction on the seed.

Number of tiller $plant^{-1}$

Figure 2 shows the effect of tillage method on number of tiller $plant^{-1}$ at 45 DAS. The highest number of tiller $plant^{-1}$ (4.4) was observed in zero till plot with residue management and the lowest number of tiller $plant^{-1}$ (1.3) was observed in conventional method. Zero till plot without residue management shows the number of tiller $plant^{-1}$ was 3.36. Zero tillage method performed better on tiller production. It keeps the seed relatively uncovered in zero tillage compared with conventional and bed method and this may caused higher tiller in zero tillage plot. It is noted that depth of sowing affects on tiller formation. Increasing in depth lower the tiller $plant^{-1}$ and mulching has no remarkable effect on tiller formation (Edward *et al*, 2006).

Plant height

Figure 3 shows the effect of tillage method on plant height at 45 DAS. The maximum plant height (44.15cm) was found in the plot of zero tillage with mulching and the minimum plant height (36.3cm) was found in conventional tillage method.

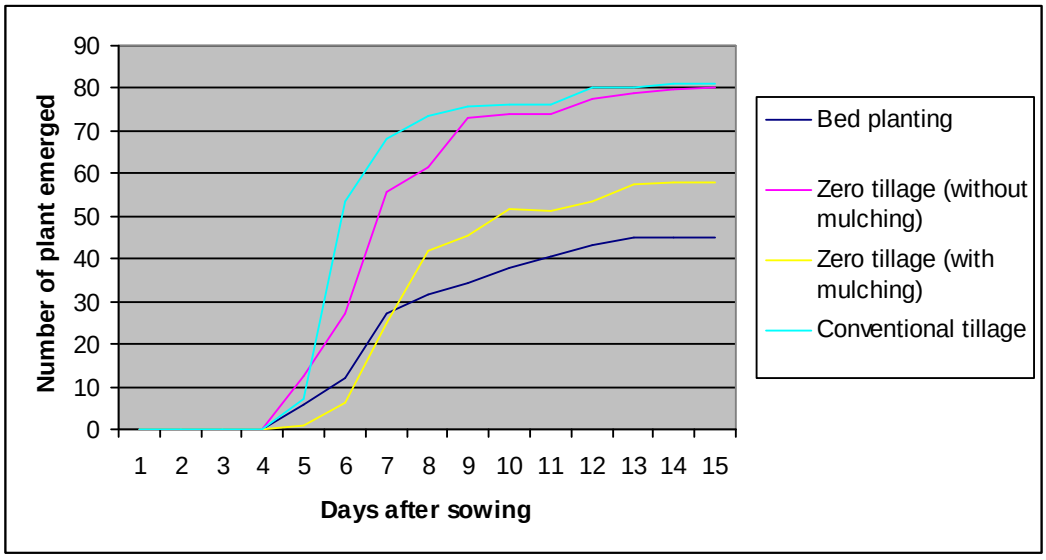

Figure 1. Effect of tillage option on emergence rate

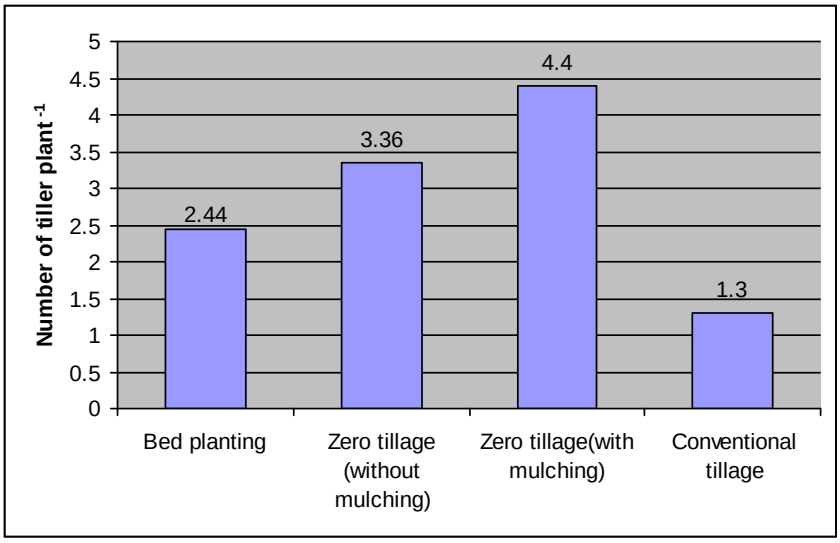

Figure 2. Effect of tillage option on number of tiller plant^{-1}

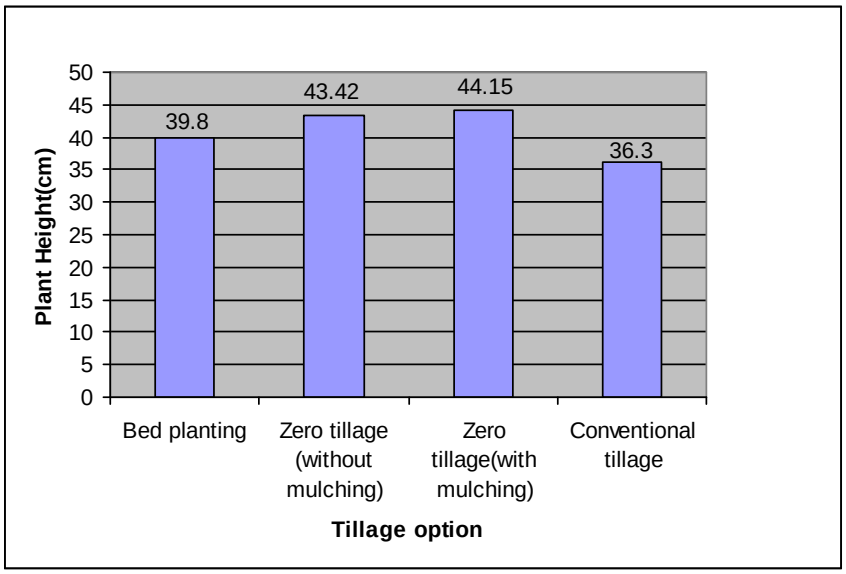

Figure 3. Effect of tillage option on plant height

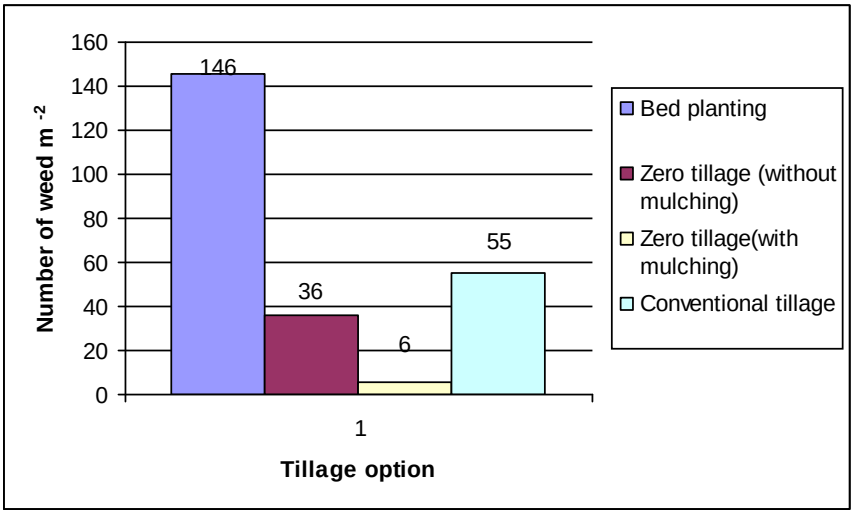

Figure 4. Effect of tillage option on weed growth

Weed growth

Figure 4 shows the maximum number of weed grown m^{-2} (146) in the bed planting method. It may due to the pulverization of soil by the bed planter and thus weed seed got proper environment for germination. The minimum number (6) of weed grown m^{-2} of the plot of zero tillage with mulching. It may due to the shadow effect from the mulching materials. This indicates that mulching has positive impact on weed control.

till plot also attacked less than conventional plot by the rodent. Rodent attack was found lowest in bed method due to have clear observation path between the two beds.

Economic yield, t ha^{-1}

Yield of wheat was found maximum (3.312 t ha^{-1}) in the plot of zero tillage without residue management and followed by the zero tillage with residue management, bed planting and conventional method with the value of 3.127 t ha^{-1}, 3.097 t ha^{-1}

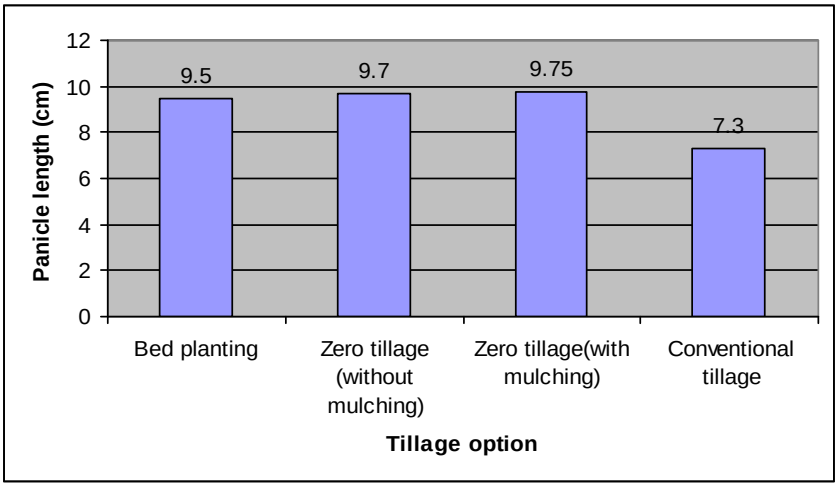

Figure 5. Effect of tillage option on panicle length

Table 2. Yield data of wheat cultivation

	Method of planting			
	Bed planting	Zero tillage (without mulching)	Zero tillage(with mulching)	Conventional tillage
100 seed weight, gm	4.67	4.13	4.27	4.03
Economic yield, t ha^{-1}	3.097	3.312	3.127	2.59
Biological yield, t ha^{-1}	4.128	5.246	4.940	4.501
Harvest Index	0.750	0.631	0.633	0.575

Table 3. Cultivation cost of wheat crop

Planting Method / Cost category	Bed planting Tk. ha^{-1}	Zero tillage (without mulching) Tk. ha^{-1}	Zero tillage(with mulching) Tk. ha^{-1}	Conventional tillage Tk. ha^{-1}
Land preparation cost	0	0	0	2000
Seed cost	5640	5640	5640	7050
Planting cost	1655	1471	1471	700
Fertilizer cost	5450	5450	5450	5450
Herbicide cost	4450	4450	4450	4450
Mulching cost	-	-	2900	-
Weeding cost	5556	2778	347	4167
Harvesting & threshing cost	9000	9000	9000	9000
Total cultivation cost	31751	28789	29258	32817
Yield, t ha^{-1}	3.097	3.312	3.127	2.59
Total return, t ha^{-1}	74328	79488	75048	62160
BCR	2.34	2.76	2.57	1.89

Panicle length

The highest panicle length (9.75cm) was observed in zero tillage method with residue management and the lowest length (7.3cm) was observed in conventional method.

Attack of rodent

In this study it was found that the intensity of rat attack is more in conventional plot due to darkness created by the crop. Zero

and 2.59 t ha^{-1} respectively (Table 2). As the initial moisture content of the field was high the residue management hindered the yield of wheat in the plot of zero tillage with residue management.

Biological yield, t ha^{-1}

The biological yield was found highest (5.246 t ha^{-1}) in zero tillage without mulching and lowest (4.128 t ha^{-1}) in bed

method (Table 2). Biological yield in the plots of zero tillage (with mulching) and bed planting were 4.940 t ha^{-1} and 4.501 t ha^{-1} respectively.

Harvest index

Harvest index was found highest (0.750) in bed method and followed by zero tillage with residue management (0.633), zero tillage without residue management (0.631) and conventional method (0.575) (Table 2).

100 seed weight, g

Highest 100 seed weight (4.67 g) was found from the bed method and lowest was 4.03 g from the conventional method. The weight of 100 seed found from zero tillage with residue management and zero tillage without residue management were 4.27 g and 4.13 g respectively (Table 2).

Production cost and benefit cost ratio (BCR)

After detail calculation total cultivation cost and BCR for different tillage method have presented in the table 3. Maximum cost was taken place in the conventional tillage practice and it is due higher weeding cost, seed cost and planting cost. Minimum production cost observed in zero tillage without residue management due to absence of land preparation cost. Difference in cultivation cost between zero tillage without residue management and zero tillage with residue management is negligible. Although zero tillage with residue management practice consists of extra mulching cost than zero tillage without residue management. The weeding cost is very less in zero tillage with residue management method. Maximum value of BCR (2.76) was found for zero tillage without residue management practice and minimum value (1.89) was found for conventional method of cultivation (Table 3).

Conclusion

From this study it was found that all the growth parameters such as tiller $plant^{-1}$, plant height and panicle length were highest in zero tillage with residue management method and the biological yield was highest in zero tillage without residue management method due to better emergence rate. Economic yield was found highest (3.312 t ha^{-1}) in the zero tillage without residue management method and lowest (2.59 t ha^{-1}) in conventional method. Harvest index was found highest (0.75) in bed planting method due to highest seed weight (4.67 gm per 100 seed). Total cultivation cost were Tk. 31751 ha^{-1}, Tk. 28789 ha^{-1}, Tk. 29258 ha^{-1} and 32817 Tk. ha^{-1} for bed, zero without residue, zero with residue and conventional method respectively and the BCR were 2.34, 2.76, 2.57 and 1.89 for bed, zero without residue, zero with residue and conventional method respectively. Intensity of rodent attack was lowest in bed method and highest in conventional method. Finally it can be concluded that zero tillage without residue management gave better results than other tillage option. Residue management showed negative impact due to high moisture content therefore it is recommended to continue the same program with less soil moisture during planting operation.

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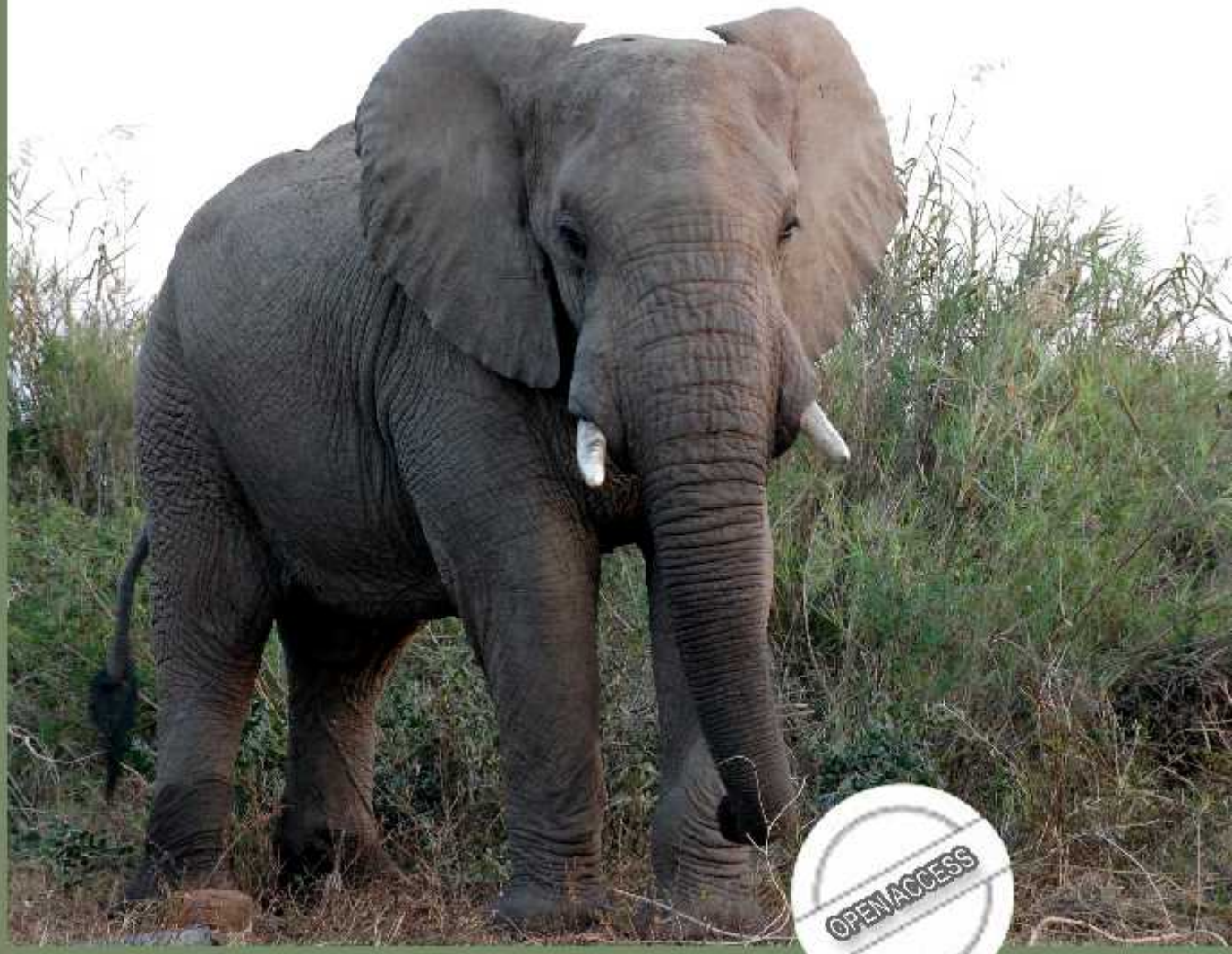

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