Study on Performance of Conservation Tillage Equipment for Wheat and Maize Planting in Nepal

Shreemat Shrestha[1]

ABSTRACT

Aiming at the reduction of cost of cultivation and maintaining the sustainability of soil crop agro ecosystem, different conservation tillage equipment were tested and some adapted to local conditions in the past few years by the Nepal Agriculture Research Council (NARC) in Nepal.

Minimum tillage by single pass roto tiller, minimum till drill (Chinese seed drill) operated by power tiller, power tiller operated strip till (modified from minimum till drill), four-wheel tractor drawn zero till drill and manually operated maize planter (Jab seeder) were tested in on-station and on-farm conditions of Nepal. Based on on-farm studies conducted at Bhaktapur in 2003-2004, it was concluded that single pass of power tiller operated roto-tiller saves cost for land preparation by 40 per cent than tillage by 2 passes of power tiller with roto-tiller (local practice) with about 5 per cent increased average yield of wheat. Similarly, based on on-farm study conducted at Bhaktapur in year 2005-2006, it was concluded that minimum till drill (Chinese seed drill) saves cost for land preparation by 61 per cent than tillage by 2 passes of power tiller with roto-tiller (local practice) with about 22 per cent increased average yield of wheat. The minimum till drill is modified into strip till drill by replacing the blades and furrow openers at Rs. 4000 additional cost.

On station comparative study of strip till drill with minimum till drill at Khumaltar farm in 2005-2006 indicates that strip till saves 26 per cent of cost of land preparation and sowing cost in wheat sowing with 4 per cent increased yield. Study conducted in Belwa VDC indicates that the zero till drill saves about 65 per cent of the cost of tillage and seeding than the traditional practice and with 4 per cent increase in yield of wheat. The Jab seeder is adapted into Nepalese condition for no till cultivation of maize especially, for the hill areas. It has a field capacity of .66 ha/hr in no till condition. The plant emergence and plant stand is found to be better in Jab seeder dibbled plot than tilled plot with manual seeding. From these studies it is identified that there is need of further research in identifying the appropriate soil cover and method of application of farm yard manure in no till condition in the hills of Nepal.

Key words: Conservation tillage, minimum till drill, zero till drill, Jab seeder

[1] Engineer, Agricultural Engineering Division, Nepal Agricultural Research Council, PO Box 10376, Kathmandu, Nepal , Tel: 00977-1-5524351, Fax: 00977-1-4262500, Email: Shreemat@narc.gov.np

1. INTRODUCTION

Agriculture is the backbone of Nepal's national economy, is the means of livelihood for majority of the population, main source of GDP, income and employment opportunities of the country. Agriculture contributes to about 38 per cent to national GDP and provides part- and full-time employment opportunities to 80 per cent of its population. Rice, maize and wheat are major cereal crops cultivated in 1.4, 0.87 and 0.73 million hectares and covers more than 91 per cent of total cultivated area (MOAC, 2007).

In the terai (flat land) rice-based cropping system is dominant whereas in the hills, maize-based cropping system is dominant. The major challenge of the agricultural system in Nepal is to feed the growing population of the country which at present is 25 million. However, the long-term fertility of rice wheat system indicates stagnating and declining yields of rice and wheat crops (Regmi et. al 2002). Similarly maize-based system in the hills is under threat due to soil fertility decline resulting from soil erosion and nutrient losses through runoff and leaching (Tripathi et. al 2000). Even though overall national yield data of these cereal crops indicates that it is increasing slowly, yet, the factor productivity and profitability is declining due to soil fertility decline, weed problem, disease and insects, labour /power scarcity, high cost of inputs. (Tripathi, J et al 2003)

In this context, it is realized that conservation agriculture (CA) could be an ultimate solution to enhance the production and productivity and maintaining the sustainability of the agro-ecosystem.

To move forward CA, tillage is the major component of the system. Conservation tillage is a set of practices that leave crop residues on the surface which increases water infiltration and reduces erosion. It is a practice used in conventional agriculture to reduce the effects of tillage on soil erosion. However, it still depends on tillage as the structure-forming element in the soil. Nevertheless, conservation tillage practices such as zero tillage practices can be transition steps towards CA (FAO, conservation agriculture website).

The tillage equipment has a major role in providing good germination of crops planted into the soil that is not tilled and where residue mulch occurs on the soil surface. Similarly, it should also contribute in the proper placement of fertilizer for increased efficiency. Hence, to reduce overall cost input and to create favourable environment for crop establishment, conservation tillage implement has a major role.

Animate (animal and human) power is the dominant power source used for tillage. Yet, less work has been done in conservation tillage by focusing on the animate power due to the lack of human resource in Nepal. Use of four-wheel tractors in terai plains and two-wheel tractors in the valleys and hills with road access is increasing. According to the

National Sample Census of Agriculture (NCA) 2001/02, there are 273000 holdings using tractors for agricultural operation mainly for tillage which accounts to 8 per cent of the whole country holdings and 17 per cent of holdings in the terai. After the introduction of the Chinese power tiller in Nepal, it is considered to be appropriate for tillage and transportation in the hilly areas, valleys and terai due to cost factor, simplicity of the machine, and robust design matching with the small sizes of land holdings of the country. According to NCA 2001/02, more than 15600 holdings were using power tillers for tillage.

Under the banner of resource conservation technologies (RCT), different conservation tillage equipment were tested and some adapted to local conditions in the past few years in Nepal by the Nepal Agriculture Research Council (NARC) with the support from CIMMYT and Rice Wheat Consortium (RWC). This paper describes different conservation tillage equipment tested/ adapted in Nepal.

2. MATERIALS AND METHODS

Different conservation tillage implements vis-à-vis minimum tillage equipment, minimum till drills, zero till drills and jab seeders were tested in agricultural research stations and farmers fields in past several years in Nepal. Some of the conservation tillage equipment (such as strip till drill and Jab seeder) were modified/adapted and tested in Nepalese conditions.

2.1 Minimum tillage by power tiller with roto-tiller

Comparative study on the common tillage practice and minimum tillage practice by using power tiller roto-tiller in wheat crop in rainfed conditions was conducted in Bhaktapur in 2003-2004. The comparative study was conducted in seven locations in the farmers' fields of Katunje VDC of Bhaktapur district. A comparative study was conducted in the plot of at least 250 sq. m. in which wheat seeding was performed by single pass tillage and double pass tillage by power tiller roto-tiller drill. The evaluation of the performance of crop and machine were performed with active participation of the farmers. Since the farmers are reluctant to use crop residues for soil cover due to high demand of rice straw for animal feed and mushroom farming, no extra soil cover except the rice stubble of about 15 cm height was left in the field.

2.2 Minimum tillage by using minimum till drill

Comparative study on the minimum till drill (Chinese) with the traditional tillage practice was performed in the farmer's fields of 15 locations in Bhaktapur district for cultivating wheat crop in rainfed condition in 2005-2006. Comparative study was conducted in the plot of at least 250 sq. m. In minimum tillage plot, wheat seeding was performed by single pass of the power tiller operated minimum till drill; whereas in the check plot, the farmers' practice is two passes of power tiller tillage, manual broadcasting of wheat seed and

covering by hand hoe. Similarly in this study, extra soil cover materials were not used. The evaluation of the performance of machine and crop were performed with active participation of the farmers.

2.3 Minimum tillage by minimum till drill modified into strip till drill

The six-row minimum till drill (Chinese) was modified into strip till drill by using 24 numbers of straight blades instead of 48 curved blades, which tills 2 cm width of soil in 6 rows. Moreover, the furrow openers of minimum till drill were also replaced by 6 numbers of T-type furrow openers. The performances of the strip till drills were performed at Khumaltar farm in 2005-2006. In this study, only the rice stubble of 15 cm height is used as soil cover.

2.4 Zero tillage by Pantnagar zero till drill

Comparative testing of four-wheel tractor operated Pantnagar zero till drills were performed in the farmers' field with the local practice to sow wheat in Belwa VDC of Parsa district in 1998-2001. The performance of seed drill and the wheat crop were evaluated with the active participation of the farmers. In this study, only the rice stubble of 15 cm height is used as soil cover.

2.5 Dibbling by modified Jab seeders

By aiming at the local commercial fabrication of the Jab seeder, it was modified/ adapted by using flat bar frame, plastic seed and fertilizer box and slotted nylon rod (for metering fertilizer) and adding marker rod for correct placement of seed maintaining plant to plant distance. The size (height) of the seeder was also adapted to be suitable for Nepalese farmer's average height. The Jab seeder was tested at Khumaltar and farmers' field in the year 2005 for dibbling maize in rainfed condition.

3. RESULTS AND DISCUSSION

The results and discussion on the performance of different conservation tillage equipment tested are as follow:

3.1 Minimum tillage by power tiller with roto-tiller

The study result indicates that single pass of roto tiller by 12.6 hp power tiller saves time as well as cost for land preparation of Rs. 138 per ropani (Rs. 2760 per ha) than wheat seeding by two pass of power tiller. In spite of increased size of clods (maximum size of 2.5 cm against 3.8 cm), the average crop yield in single pass of rotary tillage driven by power tiller is found to be about 5 per cent more (4261.96 kg/ ha against 4021.50 kg/ha) than from the plots of 2 passes of tillage in rainfed situation. Even though the comparative moisture monitoring was not performed in this farmer's field study, the increased yield is considered to

be mainly due to the conservation of residual moisture, in the single pass tillage plots. After observing the performance of increased yield of wheat in minimum tillage condition with less cost of land preparation, all the participating farmers preferred the single pass minimum tillage method of wheat cultivation. .

Table 1: Comparative test results of minimum tillage (single pass tillage) by power tiller with roto-tiller with farmer's practice (double pass tillage).

SN	Parameters	Single pass	Double pass
1	Average time taken for land area 1 ropani* (minutes)	48.3	81.5
2	Maximum size of clod (cm)	3.8	2.5
3	Average land preparation cost per ropani in NRs.#	201.25	339.58
4	Wheat variety used	Annapurna 4	Annapurna 4
5	Replication (number of farmers' field)	7	7
6	Average wheat yield (kg/ha)	4261.96**	4021.50**

*1 ropani is 1/20th of a hectare; #Nepalese Rupees 1US$=65 NRs.** $LSD_{.05}$ =0.247 t/ha

3.2 Minimum tillage by minimum till drill

The study results indicate that wheat seeding by using minimum till drill saves significant time (31.5 minutes against 79.6 per ropani) and average cost of land preparation (Rs. 131.25 against Rs. 331.67 ropani) in wheat sowing. Moreover, average wheat yield by minimum till drill is found to be about 22 per cent higher than local practice is mainly due to the increased conservation of residual soil moisture and better germination due to seed and soil contact in the plot of the minimum till drill. All the participating farmers preferred the minimum till drill than the local practice due to the increased grain yield and decreased cost of cultivation. However, farmers were reluctant to purchase the minimum till drill (Chinese Seed Drill) for the next season due to the high cost (Rs. 37000 per set) and poor economic capability of the farmers.

Table 2: Comparative test results of minimum tillage by power tiller operated minimum till drill with farmers' practice.

SN	Parameters	Minimum till drill	Farmer's practice (PT roto-till-2 pass)
1	Average time taken for land area 1 ropani* (minutes)	31.5	79.6
2	Maximum size of clod (cm)	1.5	2.7
3	Average land preparation cost per ropani in NRs.#	131.25	331.67
4	No. of farmers field	15	15
5	Farmer's field location and wheat yield (t/ha)		
a	Gundu(n=5)	3865.1	4579.73

b	Katunjey(n=5)	3327.81	4134.43
c	Kewachowk(n=5)	3654.83	4601.33
7	Average wheat yield (kg/ha)	3615.91	4438.5

*1 ropani is 1/20th of a hectare; #Nepalese Rupees 1US$=65 NRs.

3.3 Minimum tillage by minimum till drill modified into strip till drill

The modification of the minimum till drills into strip till drill costs about Rs.4000 per set due to the replacement of blades and furrow opener. The machine can be modified in small rural workshops. The study results indicate that strip till drill saves about 25 per cent of time (24.6 minutes against 33.3 minutes per ropani) and reduce cost of land preparation and wheat seeding (Rs.102.5 per ropani against 138.75 per ropani) significantly. The average yield of wheat was found to be about 5 percent more than that of minimum till drill. It was found to be mainly due to conservation of residual soil moisture and increased germination of seed in strip till drill because the average plant that emerged after 15 days were 299 against 231 in strip till drill plot. The operator also found it easy to control the wheat seed drill because it makes six tracks by straight blades while in operation.

Table 3: Comparative tests of wheat sowing by power tiller operated strip till drill (modified from minimum till drill) with that of minimum till drill.

SN	PARAMETERS	Minimum till drill	Strip till drill
1	Average time taken for land area 1 ropani* (minutes)	33.3	24.6
2	Average land preparation cost per ropani in NRs.#	138.75	102.5
3	No of replications	3	3
4	Crop variety	BL1473	BL1473
5	Average number of plants emerged after 15 days	231	299
6	Average wheat yield (t/ha)	3.76**	3.95**

1 ropani is 1/20th of a hectare; #Nepalese Rupees 1US$=65 NRs.** $LSD_{.05}$ =0.13 t/ha

3.4 Zero tillage by Pantnagar Zero till Drill

Land preparation by using 11 tyne cultivator with 3-5 passes and seed and fertilizer broadcasting manually is the common practice adopted in wheat cultivation in terai. The study results of on-farm trial indicate that the wheat sown by zero till drill reduces time significantly (1.65 hrs against 5.21 hrs) and cost for land preparation and wheat sowing (Rs. 861.31 against Rs.2513) than that of local practice. Moreover, the wheat gain yield is found to be about 4 per cent more in zero till drill sown plot than that of plot sown by local practice. All the participating farmers preferred zero till drill for wheat sowing than the traditional practice because of cost reduction of wheat sowing and opportunity of timely planting. More over, the farmers asked for easy availability of zero till seed drill with subsidy.

Table 4: Comparative test results of wheat sowing by zero till drill with that of local practice.

SN	Parameters	Zero till drill	Local practice
1	Average time taken for land area 1 ha (hrs.)	2.65	5.21
2	Average land preparation cost per ha. in NRs.#	861.31	2513.0
3	No of replications	4	4
4	Crop Variety	Bhrikuti	Bhrikuti
5	Average wheat yield (t/ha)	3.88*	3.72*

#Nepalese Rupees 1US$=65 NRs. * $LSD_{.05}$ =0.58 t/ha

3.5 Maize dibbling by modified Jab seeder

The modified Jab seeder is 4.4 kg weight and capable of dibbling maize along with chemical fertilizer in tilled as well as no till condition. Average time taken to dibble maize seed in 1 ropani was 50 minutes. Similarly, for land preparation by power tiller in two passes, it took 75 minutes and manual seeding and broadcasting took 79 minutes for 1 person. Hence, the cost of land preparation and seeding is significantly reduced (Rs. 15.62 against 335.93) in maize dibbling by modified Jab seeder than the local practice. The plant is found to emerge well and plant stand was better in vegetative phase in Jab-seeded no till plots than local practice due to residual moisture conservation and easy availability of nutrients to the plants in jab-seeded plots. However, the average maize grain yield in jab seeder dibbled plot was less than that of local practice which may be mainly due to poor drainage of silty clay loam type of soil in the experimental plot with less organic matter content (0.89 per cent). Observation of the on station study plots by the several group of hill farmers got interested in the use of Jab seeder. However, they raised the question on the use of farmyard manure in maize plots in no till condition.

Table 5: Comparative test results of maize planting by modified Jab seeder and manual dibbling on land prepared by power tiller.

SN	Parameters	Maize seed dibbled by Jab seeder	Land preparation by power tiller and manual seeding
1	Average time taken for land area 1 ropani * (minutes)	50	75 for land preparation PT in 2 pass +79 seeding manually
2	Average land preparation cost per ropani in NRs.#	15.62	335.93
3	No of replications	3	3
4	Crop variety	Khumal Yellow	Khumal Yellow
5	Average maize grain yield (t/ha)	3.04**	3.52**

1 ropani is $1/20^{th}$ of a hectare; #Nepalese Rupees 1US$=65 NRs.** $LSD_{.05}$ =0.33 t/ha

4. CONCLUSIONS

The conclusions from the studies are as follow:

- Based on on-farm study conducted at Bhaktapur in 2003-2004, it can be concluded that single pass of power tiller operated roto-tiller saves cost in land preparation by 40 per cent than tillage by two passes power tiller with roto-tiller (local practice). Moreover, about 5 per cent increase in average yield in single pass power tiller operated roto-tiller tillage plots due to better conservation of soil moisture.
- Based on on-farm study conducted at Bhaktapur in 2005-2006, it can be concluded that minimum till drill (Chinese seed drill) saves cost for land preparation by 61 per cent than tillage by two passes power tiller with roto-tiller (local practice). Moreover, about 22 percent increased average yield in single pass power tiller operated roto-tiller tillage plots due to better conservation of soil moisture.
- The minimum till drill can be modified into strip till drill by just replacing the blades and furrow openers with Rs. 4000 as additional cost. On station comparative study of strip till drill with minimum till drill at Khumaltar farm in 2005-2006 indicates that strip till saves 26 per cent of cost of land preparation and sowing cost in wheat sowing with 4 per cent better yield. The strip till drill needs to be further tested in on-farm condition to get the feedback from the farmers.
- Zero till drill saves about 65 per cent of the cost of tillage and seeding than the traditional practice and with 4 per cent increase in yield. Hence zero till drills are needed to be promoted in the terai plains of Nepal by making easy the availability of zero till drills.
- The Jab seeder is adapted to Nepalese conditions. The plant emergence and plant stand is found to be better with the use of the Jab seeder dibbled plot than tilled plot with manual seeding. Lack of crop residues for soil cover due to increased demand for livestock and method of application of farmyard manure in no till condition in the hills are the further issues to be addressed before packaging the Jab seeder technology for dissemination in the hills as conservation tillage technology for the conservation of soil and moisture of agricultural land of hilly areas of Nepal.
- There is a need for further research in identifying appropriate crop residue materials for soil cover in no till and minimum till without affecting the demand of crop residue for livestock.

5. REFERENCES

Atreya, K, Sharma S and Bajracharya, R M. 2005. Minimization of Soil and Nutrient Losses in Maize-based Cropping System in the Mid-hills of Central Nepal. Kathmandu University Journal of Science, Engineering and Technology, Vol.1, No.1., September ,2005, Kathmandu University, Dhulikhel, Nepal.

FAO Conservation Agriculture Website. 2006.

http://www.fao.org/waicent/faoinfo/agricult/ags/AGSE/agsee/general/OBJECT.htm

Hobbs, P R. Conservation Agriculture: What Is It and Why Is It Important for Future Sustainable Food Production?

Meisner, C.A and M Bodruzzman, M R Amin, E Bakshi, Abs Hossain , M Sadat. 2001.Conservation Tillage Options for the Poor Small Landholders in South Asia. Paper Presented at World Congress on Conservation Agriculture, Madrid, 1-5 October, 2001.

MOAC .2007. Selected Indicators of Nepalese Agriculture and Population. Government of Nepal, Ministry of Agriculture and Co-operatives, Singh Durbar, Kathmandu, Nepal.

Rajbhandari, N P. 2000. Declining Soil Fertility Constraints in Maize Production in the Hills: A Review of Recent Surveys of Farmers Practices, Perceptions and Conceptualizing a Basis for Proper Targeting of Maize Research in the Hills. In: B P Tripathi, N P Rajbhandari and J K Ransom (eds.). Improved Soil Fertility Management for Sustainable Maize Production: Proceedings of Workshop Group Meeting in Hill Maize Research Project. Nepal Agricultural Research Council /HMRP/CIMMYT Nepal.

Sah, Ganesh. 2003. Evaluation of Tillage and Crop Establishment Methods for Wheat Production. Proceedings of Wheat Research Papers Presented at the 25th National Winter Crop Research Workshop, National Wheat Research Program, Bhairahawa Nepal.

Tripath, B P, S P Shrestha and G P Acharya. 2000. Summary and Updating with 1999 Season Soil and Nutrient Loss from Bari Land Terraces in Western Hills of Nepal: An Overview. Lumle Seminar Paper No 99/9. Agriculture Research Station, Lumle, Kaski, Nepal.