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

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Abstract

Aiming the reduction of cost of cultivation and maintaining the sustainability of soil crop agro ecosystem, different conservation tillage equipments were tested and some adapted to local condition in past few years by 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), 4 wheel tractor drawn zero till drill and manually operated maize planter (Jab seeder) were tested in on-station and on-farm condition of Nepal. Based on on-farm study conducted at Bhaktapur in year 2003/4, it is concluded that single pass of power tiller operated roto-tiller saves cost for land preparation by 40 percent than tillage by 2 passes of power tiller with roto-tiller (local practice) with about 5 percent increased average yield of wheat. Similarly, based on on-farm study conducted at Bhaktapur in year 2005/6 it is concluded that minimum till drill (Chinese seed drill) saves cost for land preparation by 61 percent than tillage by 2 passes of power tiller with roto-tiller (local practice) with about 22 percent increased average yield of wheat. The minimum till drill is modified in to strip till drill by just replacing the blades and furrow openers with Rs. 4000 additional cost. On station comparative study of strip till drill with minimum till drill at Khumaltar farm in 2005/6 indicates that strip till saves 26 percent of cost of land preparation and sowing cost in wheat sowing with 4 percent increased yield. Study conducted in Belwa VDC indicates that the zero till drill saves about 65 percent of the cost of tillage and seeding than the traditional practice and with 4 percent increase in yield of wheat. The jab seeder is adapted in to Nepalese condition for no till cultivation of maize specially, for the hills of Nepal. It has the 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 if Nepal.

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

1. Introduction

Agriculture is the backbone of national economy, means of livelihood for majority of population, main source of GDP, income and employment opportunities of Nepal. The agriculture contributes to about 38% to national GDP and provides part and full time employment opportunities to 80% of its population. Rice, maize and wheat are major cereal crops cultivated in 1.4, 0.87 and 0.73 million hectare and covers more than 91 percent of total cultivated area of Nepal (MOAC, 2007). In the terai (flat land) rice based cropping system is dominant where as 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 and at present it 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 due to 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 but 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 could be ultimate solution to enhance the production and productivity and maintaining the system sustainability of agro eco system.

To move toward the conservation agriculture, 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 Conservation Agriculture." (FAO, conservation agriculture website). The tillage equipment has major role in providing good germination of crops planted into soil that is not tilled and where residue mulch occurs on the soil surface. Similarly, it should also contribute in proper placement of fertilizer for increased efficiency. Hence to reduce overall cost input and to create favorable environment for crop establishment, conservation tillage implement has got major role.

Animate (animal and human) power is the dominant power source used for tillage. But very less work has been done in conservation tillage by focusing the animate power due to lack of human resource in Nepal. Use of 4 wheel tractors in terai plains and 2 wheel tractors in the valleys and hills with road access is increasing. According to National Sample Census of Agriculture (NCA) 2001/02, 273000 holding are using tractors for agricultural operation mainly tillage which accounts 8 percent of whole Nepal and 17 percent of holdings in terai. After the introduction of 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, simple and robust design and matching with the small land holding size of the country. According to NCA 2001/02, more than 15600 holdings were using power tiller for tillage.

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

2. Materials and Methods

Different conservation tillage implements viz. minimum tillage equipments, minimum till drills, zero till drills and jab seeders were tested in agricultural research stations and farmers field in past several years in Nepal. Some of the conservation tillage equipments (such as strip till drill and Jab seeder) were modified/ adapted and tested in Nepalese condition.

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 rain fed condition was conducted in Bhaktapur in the year 2003/4. The comparative study was conducted 7 locations in the farmer's field of Katunje VDC of Bhaktapur district. 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 residue 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) 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 2005/6. 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 power tiller operated minimum till drill; where as in the check plot the farmers' practice i.e. 2 pass of power tiller tillage, manual broadcasting of wheat seed and covering by hand hoe. Similarly in this study also 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 in to strip till drill

The six-row minimum till drill (Chinese) was modified in to strip till drill by using by using 24 numbers of straight blades instead of 48 numbers of 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 opener. The performances of the strip till drills were performed at Khumaltar farm in F Y 2005/6. In this study also 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 farmer's field with the local practice to sow wheat in Belwa VDC of Parsa district in the year 1998 to 2001. The performance of seed drill and the wheat crop were evaluated with the active participation of the farmers. In this study also only the rice stubble of 15 cm height is used as soil cover.

2.5 Dibbling by modified jab seeders

By aiming 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 jab seeder was also adapted to make suitable for Nepalese farmer's average height. The jab seeder was tested at Khumaltar and farmer's 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 equipments tested are as following.

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 percent more (4261.96 kg/ ha against 4021.50 kg/ha) than from the plots of 2 pass of tillage in rain fed 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: Results of 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 of 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 farmer's 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 percent higher than local practice it is mainly due to the more conservation of residual soil moisture and better germination due to seed and soil contact in the plot of minimum till drill. All the participating farmers preferred the minimum till drill than local practice due to increased grain yield and decreased cost of cultivation. However farmers were reluctant to purchase the minimum till drill (Chinese Seed Drill) for next season due to high cost Rs. 37000 per set and poor economic capability of the farmers.

Table 2: Results of comparative test results of minimum tillage by power tiller operated minimum till drill with farmer's 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 of 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 in to strip till drill

The modification of the minimum till drill in to strip till drill costs about Rs.4000 per set due to replacement of blades and furrow opener. It can be modified in small rural workshop. The study results indicate that strip till drill saves about 25 percent 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 is found to be about 5 percent more than that of minimum till drill. It is found to be mainly due to conservation of residual soil moisture and increased germination of seed in strip till drill because in strip drill plot average plant emerged after 15 days were 299 against 231 in strip till drill plot). The operator also found easy to control the wheat seed drill because it makes six tracks by straight blades while in operation.

Table 3: Results of comparative test results 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 $1/20^{th}$ of a hectare; #Nepalese Rupees 1US$=65 NRs.** $LSD_{.05}$ =0.13 t/ha

3.4 Zero tillage by Pantnagar Zero till Drill

The 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 teri. The study results of on farm trial indicate that the wheat sown by zero till drill reduces significant time (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 percent 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 reduction of cost 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: Results of 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 of 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 it 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 be emerged 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 of the experimental plot with less organic matter content (0.89%). Observation of the on station study plots by the several group of hill farmers got interested in use of jab seeder. However they raised the question of use of farmyard manure in maize plots in no till condition.

Table 5: Results of 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 & 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 1/20th of a hectare; [#]Nepalese Rupees 1US$=65 NRs.** $LSD_{.05}$ =0.33 t/ha

4. Conclusions

The conclusions of the studies are as follows

- Based on on-farm study conducted at Bhaktapur in year 2003/4 it can be concluded that single pass of power tiller operated roto-tiller saves cost for land preparation by 40 percent than tillage by 2 passes power tiller with roto-tiller (local practice). Moreover, about 5 percent increased 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 year 2005/6 it can be concluded that minimum till drill (Chinese seed drill) saves cost for land preparation by 61 percent than tillage by 2 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 in to strip till drill by just replacing the blades and furrow openers with Rs. 4000 additional cost. On station comparative study of strip till drill with minimum till drill at Khumaltar farm in 2005/6 indicates that strip till saves 26 percent of cost of land preparation and sowing cost in wheat sowing with 4 percent better yield. The strip till drill needs to be further tested in on farm condition to get the feed back from the farmers.
- Zero till drill saves about 65 percent of the cost of tillage and seeding than the traditional practice and with 4 percent increase in yield. Hence zero till drills needed to be promoted in the terai plains of Nepal by making easy availability of zero till drills.
- The jab seeder is adapted in to Nepalese condition. The plant emergence and plant stand is found to be bettering jab seeder dibbled plot than tilled plot with manual seeding. Lack of crop residue for soil cover due to increased demand for livestock and method of application of farm yard 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 hills of Nepal.
- There is need of further research for identifying appropriate crop residue material for soil cover in no till and minimum till without affecting the demand of crop residue for livestock.

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 productionin 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: proceeding 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 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.