Original Research Article

Efficacy of Different Tillage and Weed Management Practices on Phenology and yield of Winter Maize (*Zea mays* L.) i~~I~~n Chitwan, Nepal

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ABSTRACT

A field research trial at experimental station of National Maize Research Program (NMRP), Rampur, Chitwan, Nepal during winter 2015/16 was conducted to study the effects of different tillage and weed management practices on yield and yield attributing characters of winter maize *(Zea mays* L.). The experiment was laid out in split plot design with two tillage methods (no tillage and conventional tillage) as main plot factor and seven weed management practices as sub plot factor (sequential application of atrazine 0.75 a.i. kg/ha *fb* 2,4-D at 1.5 kg/ha; pre-emergence tank mix application of atrazine at 0.75 kg/ha and glyphosate at 2.5 ml/~~liter~~ L of water; pre-emergence tank mix application of atrazine at 0.75 kg/ha and pendimethalin at the rate 2 ml/~~lit~~ L of water; cowpea co-culture; black polythene mulch, weed free and weedy check). From the study, the highest grain yield (7.07 t/ha) was obtained from black polythene mulch which was statistically similar to weed free check (5.91 t/ha). The other weed management practices produced intermediate yield between black polythene mulch and weedy check which produced the lowest grain yield (3.16 t/ha). Also, tillage methods significantly influence the harvest index, significantly higher harvest index was found in no tillage (46.49%) as compared to conventional tillage practices (42.12%).

Keywords: Tillage; Weed management; Efficacy; Maize; Nepal; Yield.

1. INTRODUCTION

Maize traditionally grown as a staple food crop for many years, and is the second most important crop after rice in terms of area and production in Nepal. Better yield potential, short duration, superior nutritional content (about 72 % starch, 10 % protein, 4.8 % oil, 9.5 % fiber, 3 % sugar, and 1.7 % ash) [1] and equally important for fodder as well as for grain implies the maize as "Queen of cereals". During 2014 to 2016, on average maize is grown in area of 900,913 hectares with total production of 2,220,010 tons and average yield of 3.09 t/ha [2]. It is being grown in diverse climatic and geographic regime ranging from tropical to temperate zone.

Weed, a plant grown where it is not desirable, declines yield and quality of crop plants and leads to higher cost in food production [3] and also regarded as greatest limiting factor in efficient crop production. Thus, weed is the major problem for losing the yield potential of crop (37%) as compared to other loss potential i.e. animal pest 18%, fungal and bacterial pathogen 16%, and virus 2% [4]. Maize yield losses due to weeds depend on the cultivars, species and number of weeds per unit area, crop-weed competition period and duration. Besides reducing yield, weeds can reduce grain quality, cause irregular maturation and harvesting difficulties, as well as act as alternate hosts for pests and pathogens. Thus, the need for increasing maize yield has called for better crop management practices including efficient weed control strategies to enhance the productivity. Since, different weed control practices like cultural, physical, biological and chemical are used for weed control. No doubt cultural methods are still useful tools but are laborious, time consuming and getting expensive. Also, soil moisture and temperature are affected by tillage system, potentially affecting weed and crop germination conditions, growth and yield of crop. Among the crop production factors, tillage contributes up to 20% [5]. With the development and widespread adoption of minimum and zero-tillage systems these days, weed management approaches have evolved. But their economic and geographical based validation is lacking.

The scenario needs an effective intervention through genuine research findings on the best weed management practice for increasing productivity of maize crop while maintaining the ecological and economical sustainability at the same time. The best results of weed control can only be seen in case of integrated weed management practices. Integrated weed management is the need of the day, because of its sustainability and higher productivity [6]. Therefore, an attempt was made in order to evaluate the efficacy of tillage and weed management on yield attributes and yield of winter maize.

2. MATERIALS AND METHODS

Research was conducted in the research block of NMRP (National Maize Research Program under Nepal Agriculture Research Council) Rampur, Chitwan during winter season from September 2015 to March 2016. The area is situated in Central terai of Nepal which lies at $27^{0}37^{'}$ North latitude and $84^{0}25^{'}$ East longitude with the elevation of 256m above mean sea level. Split plot design was adopted for the experiment where main-plot factor represent tillage practices and sub-plot factor contained different weed management practices **(Table 1).**

Climatic condition during experimentation

The experimental site falls under the subtropical humid climate belt of Nepal which is characterized by three different seasons that prevail in the experimental site: cool winter (November to February), hot spring (March to May), and distinct rainy monsoon season (June to October). The annual precipitation of given area is about 1919.5 mm (NMRP, 2000). Weekly average data on different weather parameters i.e., maximum and minimum temperatures, total rainfall, and relative humidity, recorded during the maize growing season at NMRP are presented in Fig.~~ure~~ 1.

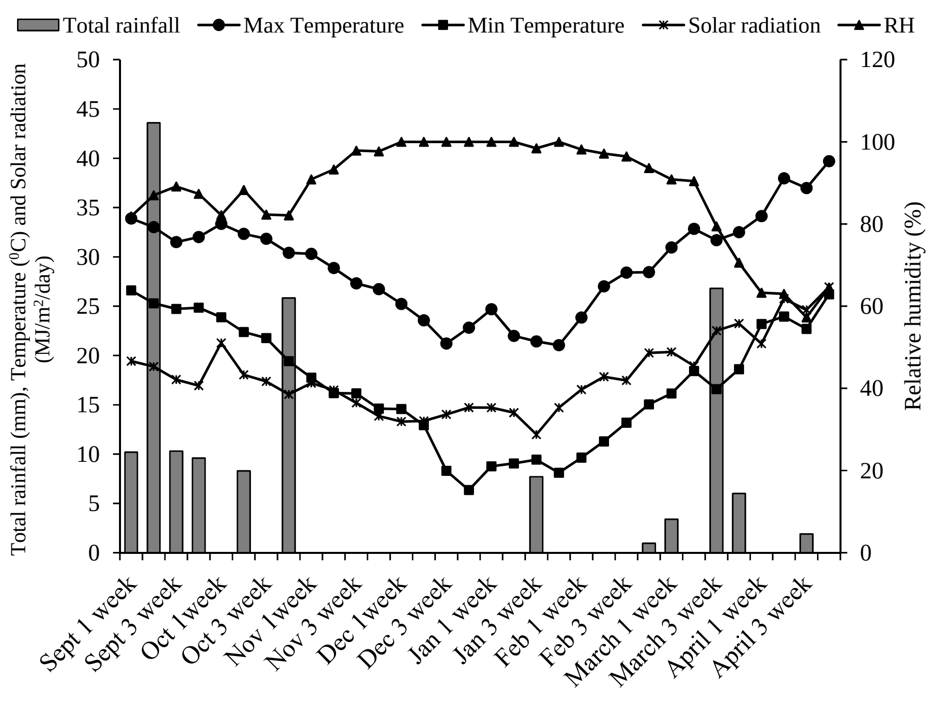

Figure 1.Weather condition during the course of experimentation at AFU, Rampur Chitwan, 2015/16

Treatment Details

Details of factor and their levels used in experiment are given below:

Main plot: Tillage

i) No tillage (NT)

ii) Conventional tillage (CT)

Sub plot: Weed management practices

Table 1. Sub-Plot Factors used for research trials (Weed management Practices)

Treatment No	Treatment practice	Frequency and doses
1	Weedy Check	
2	Weedy Free	Hand weeding at the rate 10days interval
3	Polythene Mulching	Black Polythene
4	Cowpea intercropping	Maize cowpea 1:2
5	Atrazine + Glyphosate (pre-emergence tank mixture)	Atrazine: 0.75 kg a.i. kg/ha or 1.5 kg/ha (Pre-emergence application) Glyphosate: 0.80 ~~lt~~L/ha, 1-2 kg a.i. kg/ha
6	Atrazine + Pendimethalin (pre-emergence tank mixture)	Pendimethalin: 2 ml/~~lt~~L water (1-1.5) a.i. kg/ha
7	Atrazine *fb* 2,4-D (sequential application)	2,4-D: 1.5 kg/ha

Experiment was laid out in split plot design with three replication and fourteen treatments constituting 42 plots. The size of individual plot was 6m×4m (24m^2). Bund of 1m width separate two main plots and 0.5m width separate two individual plots and each replication was separated by 1 m bund. Maize was sown continuously in line with spacing of 60 cm × 25 cm. Altogether 10 rows and 16hill per row of maize were maintained in each plots. The variety used in the experiment was "RML-32/RML-17". The hybrid "RML32/RML17" was used as a parentage and presently developed Rampur hybrid 4, which can be grown in terai and inner terai, having yield potential of 6.95 t/ha with grain color orange. Field was prepared using 2 tillage methods. In no tillage plot field was left as it is, weed was killed by treating with glyphosate at the rate 0.80 lit/ha whereas in conventional tillage field was ploughed by using tractor 10 days prior to sowing to make field fine.

Field was fertilized using common of inorganic fertilizer for hybrid maize i.e. nitrogen, phosphorus, and potash at the rate 180:60:40 kg NPK/ha were applied through Urea (46%N), DAP (18%N and 46% P_2O_5) and MOP (60% K_2O). As recommended, seed rate of 20 kg/ha was used. Harvesting of maize was done from net plot area of 12m^2 of 5 rows from each plot manually with help of sickles.

Data regarding number of harvested cob, diameter and length of the cob, number of rows per ear, grain per rows, grain per ear, weight of cob with grain and weight of grain per ear, thousand kernel weight, grain yield and straw yield, stover yield and harvest index (HI) were taken and analyzed using MSTAT and Microsoft excel and interpretations were made based on results and findings. The purpose of analysis of variance was to determine the significant effect of treatments on weeds and maize.

The crop from the net plot was harvested to record the grain yield. Grain was further dried, shelled, cleaned and weight was taken using electronic balance and at the same time moisture content was also recorded using digital moisture meter. The grain yield per hectare was computed for each treatment from the net plot yields. Grain yield was adjusted to 14% moisture by using following formula given by Paudel [7].

$$\text{Grain yield (kg/ha) at 14\% moisture} = \frac{(100-\text{MC})\times\text{plot yield(kg)}\times 1000(\text{m}^2)}{(100-14)\times\text{netplot area}(\text{m}^2)}$$

Where, MC is the moisture content percentage of the grain

Similarly, harvest index was calculated by dividing economic yield with the biological yield by using following formula;

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HI= Economic Yield (Grain yield) / Biological Yield (Biomass Yield) x 100

3. RESULTS AND DISCUSSIONS

Number of ear harvested (per hectare)

Average number of ears harvested was 69563 per hectare ranged from 60277 to 85972 ~~per hectare~~ (Table 2). Number of ear harvested was not significantly influenced by tillage methods. Comparatively higher was recorded under no till as compared to the conventional tillage.

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The tested weed management practice significantly influenced number of ear harvested. Black polythene mulch treated plots resulted in higher number of ear (85972/ha.) which was found statistically similar with weed free (76944/ha.) treatment and sequential application of atrazine *fb* 2,4-D treatment. Lowest number was obtained in weedy check plot (60277/ha) which was statistically at par with tank mixture herbicidal combinations of atrazine and pendimethalin, and atrazine and glyphosate, and maize cowpea co-culture treatments. Among herbicidal application, atrazine *fb* 2,4-D recorded highest number of ear than other treatment.

Number of kernel row per ear

Average number of kernel rows per ear was (11.19) ranging from 10.33 to 12.00 (Table 2). Kernel row per ear also was not significantly affected by tillage methods. However, number of kernel row per ear found greater in no till than conventional tillage.

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Similarly, different weed management practices significantly influenced number of kernel row per ear. Due to reduction in crop weed competition, highest number of kernel rows per ear was recorded in black polythene mulch treated plots (12.00) and which was significantly at par with all treatment including weedy check except tank mixture treatments i.e. atrazine and pendimethalin, and atrazine and glyphosate. The least number of kernels per ear was recorded in tank mixture application of atrazine and pendimethalin treated plot and it was statistically similar with the tank mixture application of atrazine and glyphosate.

Number of kernels per row

Average number of kernel per row was 27.81 ranged from 26.33 to 31.17 (Table 2). Number of kernel per row was significantly influenced by both tillage methods and weed management practices. Numbers of kernels per row was significantly higher under no tillage than under conventional tillage.

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Among different weed management practices, significantly higher number of kernels per row was observed in black polythene mulch (31.17). Further, the numbers of kernels per row recorded in rest of the treatments were statistically similar.

Number of kernels per ear

Average number of kernels per ear was 312.24 ranging from 281 to 374 (Table 2). Number of kernel per ear was significantly influenced by both tillage methods and weed management practices. The number of kernels per ear was significantly higher under no tillage than that of conventional tillage. This was also reflected on grain yield.

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Among weed management practices, significantly higher number of kernels per ear was observed in black polythene mulch (374.00). Further, the numbers of kernels per row were statistically similar.

The number of kernels per ear recorded in weed free treatment was comparable to all other herbicidal treatments but the difference was remarkable. This might be the reason for obtaining significantly higher grain yield in weed free condition as compared to all other herbicidal treatments.

Table 2. Yield attributes as influenced by tillage methods and weed management practices in winter maize at NMRP, Rampur, Chitwan, Nepal, 2015/16

Treatments	Total number	Number	Number	Number	Thousand	Sterility

	of earsharvested per ha	of kernel rows per ear~~-1~~	of kernels per row~~-1~~	~~O~~of kernels per ear~~-1~~	grain weight (g)	(%)
Tillage methods						
No Tillage	73571.43	11.33	28.76[a]	326.57[a]	201.22	16.76
Conventional Tillage	65555.56	11.05	26.86[b]	297.90[b]	208.70	15.24
LSD (p=0.05)	Ns	ns	1.434	17.42	ns	ns
Weed management Practices						
Cowpea co-culture	63750.00[c]	11.67[ab]	27.50[b]	321.00[b]	196.14	15.06[bc]
Black polythene mulch	85972.20[a]	12.00[a]	31.17[a]	374.00[a]	209.71	10.21[c]
Atrazine 0.75 kg a.i. ha^{-1} + Pendimethalin	62777.70[c]	10.33[c]	27.33[b]	282.67[b]	196.22	14.27[bc]
Atrazine 1.5 kg a.i. ha^{-1} *fb* 2,4-D	74027.70[b]	11.33[abc]	27.17[b]	308.67[b]	204.73	17.59[b]
Atrazine 0.75 kg a.i. ha^{-1} + Glyphosate	63194.40[c]	10.67[bc]	26.33[b]	281.33[b]	212.75	18.58[b]
Weed free	76944.40[ab]	11.33[abc]	28.00[b]	318.00[b]	223.17	10.61[c]
Weedy check	60277.70[c]	11.00[abc]	27.17[b]	300.00[b]	191.99	25.67[a]
LSD (p=0.05)	9065.60	0.71	2.23	44.16	ns	5.19
CV,%	19.95	8.88	9.70	15.42	11.60	43.71
Grand Mean	69563.49	11.19	27.81	312.24	204.96	16.00

Note: Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance, DAS, days after sowing ; ns, non-significant.

Thousand grain weight

Mean thousand grain weight was recorded 204.96 g (Table 2). Thousand grain weight was found to be non-significant among the tillage methods and weed management practices. However, it was found highest in weed free condition (223.17 g) which may be due to higher weed control efficiency and least was observed in weedy check plot (191.99 g).

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Sterility percentage

Mean sterility percentage was found 16.00% ranging from 10.21 to 25.67% (Table 2). Sterility percentage was not influenced by establishment tillage methods; however it was significantly influenced by different weed management practices. Least sterility percentage was recorded in black polythene mulch treated plot (10.21 %) and weedy free (10.61%). Weedy check had high influence on sterility percentage recording (25.67%).

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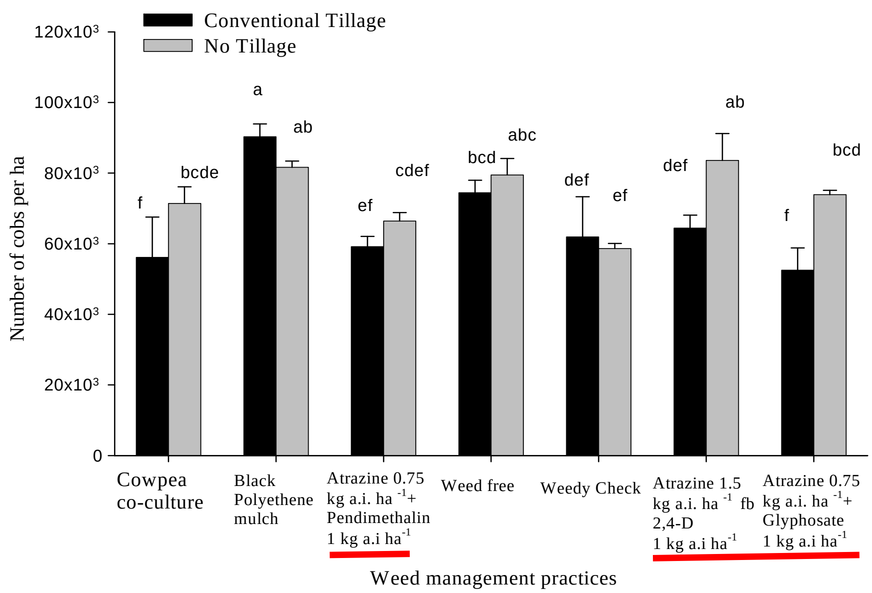

Figure 2. Interaction effect of tillage and weed management practices on number of cob per ha of winter maize at NMRP, Rampur, Chitwan, Nepal, 2015/16

Fig.~~ure~~ 2 above showed the significant interaction of tillage methods and weed management practices for number of cob per ha. For treatments black polythene mulch, weed free, weedy check and in tank mixture application of atrazine and pendimethalin, both tillage methods resulted in statistically similar number of cob per ha. Whereas, under cowpea co-culture, herbicidal tank application of atrazine and glyphosate and sequential application of atrazine and 2,4-D treatments, number of cob per hectare under no tillage was significantly higher than under conventional tillage.

Fig.~~ure~~ 3 below showed the significant interaction of tillage methods and weed management practices for number of grains rows per cob. Under all treatment except weedy check, both tillage methods resulted in statistically similar number of grain rows per cob

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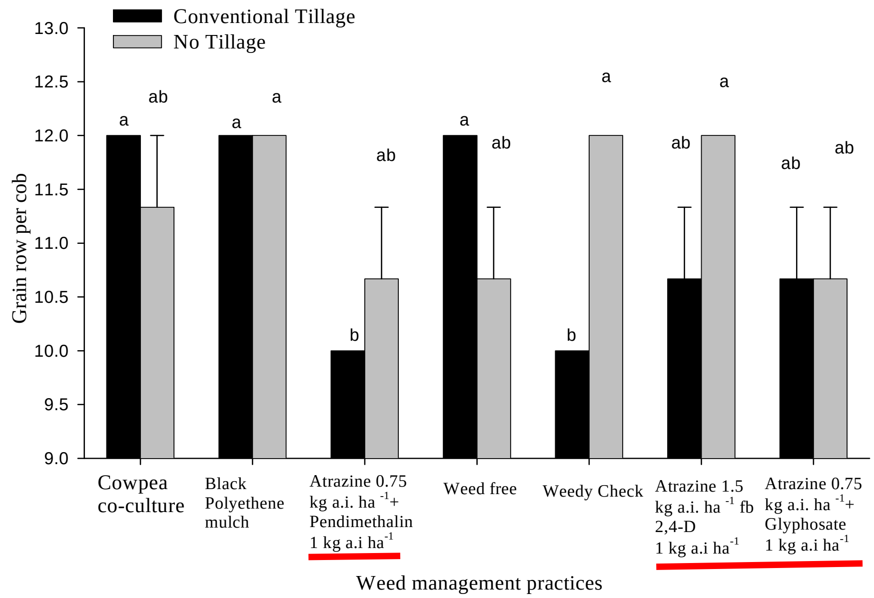

Figure 3. Interaction effect of tillage and weed management practices on grain rows per cob of winter maize at NMRP, Rampur, Chitwan, Nepal, 2015/16

Grain yield

Tillage methods also significantly influence the grain yield. Mean grain yield of the experiment was 4.78 t/ha and ranged from 3.16 to 7.07 t/ha among the treatments (Table 3). Grain yield were significantly influenced by tillage methods as well as weed management practices.

Grain yield of no tillage (5.58 t/ha) was significantly higher than conventional tillage (3.98 t/ha) as because of highest weed density and dry weight in conventional tillage practice. Weed compete with crop which in turn decreased all growth parameters and yield attributes like number of kernels per ear and thousand grain weight remarkably. Finding was supported by Karki~~, Gadal and Shrestha~~et al. [8] who found no tillage produced the highest grain yield of 5.21 t/ha as against CT with 4.75 t/ha.

Similarly, among weed management practice black polythene mulch produced the highest grain yield (7.07 kg/ha) which was statistically similar with grain yield of weedy free plot (5.91 kg/ha) and significantly superior than grain yields obtained from all other weed management practices. finding was supported by Ram~~, Sreenwar and Rani~~et al. [9] who found Higher grain yield (7.65 t/ha) in black polythene mulch higher grain yield may be due to higher weed control efficiency also due to greater value of all yield attributing characters and lower weed infestation in mulch plot. The lowest grain yield found in weedy check plot (3.16 t/ha) which might be due to competition from weed which effect yield attribute character and which found statistically similar with treatments cowpea co-culture (4.06 t/ha), tank mixture of atrazine and pendimethalin (4.11 t/ha) and tank mixture of atrazine and glyphosate applied plot (3.95 t/ha) application of atrazine *fb* 2,4-D gave satisfactory result among other chemical treated plot and the result is in close conformity with finding of Yadav et al. [10]. Deng et al. [11] reported that the key contributing factors for mulch in increasing grain yield are improved soil physical and chemical properties, and enhanced soil biological activity.

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Table 3. Grain yield(t/ha), straw yield (t/ha), harvest index (%) and weed index (%) as influenced by tillage methods and weed management practices in winter maize at NMRP, Rampur, Chitwan, Nepal, 2015/16

Treatment	Yield (t/ha)	Straw dry weight (t/ha)	Harvest Index (%)	WI
Tillage methods				
No Tillage	5.58^{a}	$6.280.33^{a}$	46.49^{a}	11.48
Conventional Tillage	$3.981.00^{b}$	$5.231.94^{b}$	42.12^{b}	25.11
LSD (=0.05)	584.20	120.10	0.679	ns
Weed management Practices				
Cowpea co-culture	4.06^{cd}	5.90^{c}	39.18^{c}	30.79^{ab}
Black polythene mulch	7.07^{a}	8.30^{a}	45.93^{abc}	-20.68^{d}
Atrazine 0.75 kg a.i. ha-1 + Pendimethalin	4.11^{cd}	4.56^{e}	46.01^{abc}	30.84^{ab}
Atrazine 1.5 kg a.i. ha-1 *fb* 2,4-D	5.18^{bc}	4.91^{de}	50.18^{a}	12.25^{bc}
Atrazine 0.75 kg a.i. ha-1 + Glyphosate	3.95^{cd}	4.86^{de}	43.86^{abc}	34.61^{ab}
Weed free	5.91^{ab}	6.69^{b}	46.80^{ab}	0.00^{cd}
Weedy check	3.16^{d}	5.03^{d}	38.20^{bc}	40.27^{a}
LSD (p=0.05)	1165.50	346.60	5.779	21.48
CV,%	38.42	25.58	14.85	167.69
Grand Mean	4.78	5.75	44.31	18.30

Note: Mean separated by DMRT and columns represented with same letter (s) are non-significant at 5% level of significance, DAS, days after sowing; ns, non-significant

Straw yield

Mean straw yield of experiments was 5.75 t/ha ranging from 8.30 t/ha in black polythene mulch to 4.56 t/ha in tank mix herbicidal application of atrazine and pendimethalin (Table 3). Straw yield was significantly influenced by both tillage methods as well as weed management practices. Gosavi [12] also reported the highest green cob and stover yield (24.67 and 30.36 t/ha respectively) under polythene mulch than control (19.44 and 23.51 t/ha respectively).

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Higher straw yield was obtained under no tillage (6.28 t/ha) as compared to conventional tillage (5.23 t/ha). However, finding was in contrast with Gul et al. [13] who resulted that conventional tillage recorded higher biological yield (7.98 t/ha) compared to no-tillage (7.70 t/ha).

Harvest index

Average harvesting index in the experiment was 44.13% (Table 3). Tillage methods significantly influence the harvest index, significantly higher harvest index was found in no tillage (46.49%) as compared to conventional tillage practices (42.12%).

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Similarly, weed management practice influence the harvest index. Highest harvest index was recorded in sequential application of atrazine *fb* 2,4-D treated plot (50.18 %) and was significantly at par with all treatment except cowpea co-culture and weedy check. Increase in percentage of harvest index as compared to weedy check may be attributed to adequate suppression of weed growth due to some residual effect as well and more availability of plant nutrients to maize crop, which favored better utilization of photo-assimilates for grain yield formation [14]. Lowest Harvest Index was found in cowpea co-culture treated plot and was statistically similar with weedy check.

Weed index

Weed index was not significantly influenced by tillage methods. But it was more than double under conventional tillage as compared to no till (Table 3). Conventional tillage recorded significantly higher weed index (25.11%) than that of zero tillage (11.48%) which may be due to higher total weed density and dry weight recorded in conventional tillage in comparison to zero tillage. This indicates 25.11% of grain yield was reduced by higher weed growth in conventional tillage.

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Similarly, weed index was significantly influenced with respect to weed management practices. Highest weed index (WI) was observed in weedy check plot (40.27%) which was statistically similar with tank mix of atrazine and glyphosate, atrazine and pendimethalin and cowpea co-culture plot. Yadav, Choudhary~~, Choudhary, and Kishor,~~et al. [14] also reported application of either atrazine or butachlor followed by 2,~~-~~4-D recorded lower weed density, weed dry weight and higher WCE in crop. Lowest WI was recorded in black polythene mulch which showed the yield increment was 20.68% above the weed free. Gul et al. [12] also and weed index recorded lower fresh weed biomass in black plastic mulch and was significantly at par with hand weed treatment.

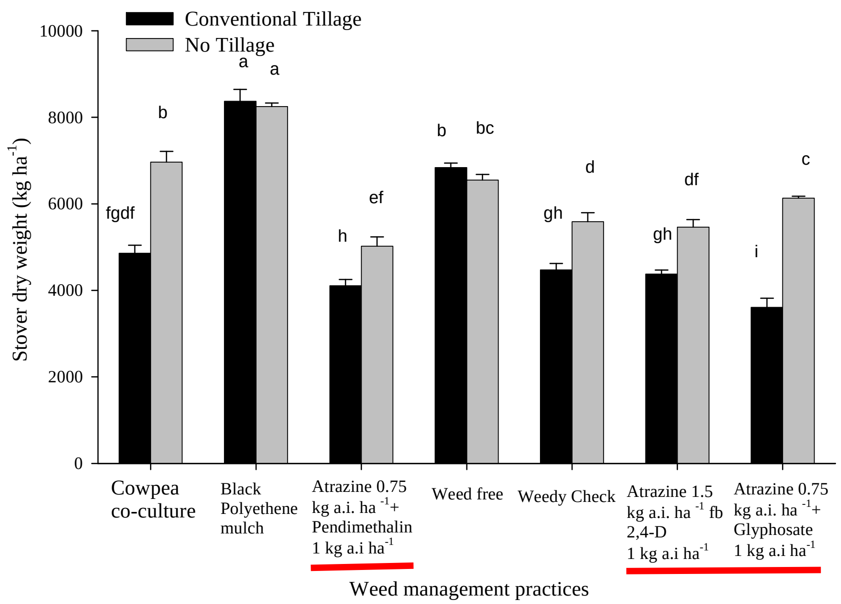

Figure 4. Interaction effect of tillage and weed management practices on Stover dry weight (t/ha) of winter maize at NMRP, Rampur, Chitwan, Nepal, 2015/16

Figure 4 showed the significant interaction of tillage methods and weed management practices for stover dry weight (t/ha). Under black polythene mulch and weed free plots, both tillage methods resulted in statistically similar stover dry weight. Whereas, for cowpea co-culture, weedy check and all herbicide applied treatment, stover dry weight under no tillage was significantly higher than under conventional tillage.

Observation on weeds

Weed flora observed in the experimental field in winter maize

Weed flora dominating throughout the research were grasses includes: *Cynodon dactylon*, *Digitaria ciliaris*, *Bidens pilosa*; sedges include *Cyperus iria*, *Cyperus rotundus*, *Fimbristylis miliacea*; broad leaf includes *Ageratum conyzoides*, *Chenopodium album*, *Brassica tourneforti*, *Amaranthus spinosus*. Mean dry weight of weeds continued to increase up to 60 DAS and found decline at 90 DAS while the density was decreased from 30 DAS (Table 5).

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Table 5. Description of weeds recorded at different growth stages of winter maize at NMRP, Rampur, Chitwan, 2015/16

Scientific name	Local name	Common name	Family	Time of appearance		
				30 DAS	60 DAS	90 DAS
Grasses						
Cynodon dactylon (L.) Pers.	Dubo	Bermuda grass	Poaceae	+	+	+
Oxalis corniculata	Chari amilo	Yellow sorrels	Oxalidaceae	+	+	
Digitaria ciliaris (Retz.) Koel.	Chittrey Banso	Crab grass	Poaceaea	+	+	+
Eleusine indica (L.) Gaertn.	Kode jhar	Goosegrass	Poaceae	+	+	+
Bidens pilosa	Kuro	Cobbler's peg	Asteraceae	+	+	
Sedges						
Cyperus iria L.	Mothe	Rice flat sedge	Cyperaceae	+	+	+
Fimbristylis miliacea	Jwane jhar	Grass like fimbry	Cyperaceae	+	+	+
Cyperus rotundus L.	Mothe	Purple nutsedge	Cyperaceae	+	+	+
Broad leaf weeds						
Ageratum conyzoides L.	Gandhe jhar	Goat weed	Compositae	+	+	+
Euphorbia hirta L.	Dudhe jhar	Garden spurge	Euphorbiaceae	+	+	
Brassica tourneforti	Ban tori	Asian mustard	Brassicaceae	+	+	+
Borreria levis (Burm. F)	Marote	Button weed	Rubiaceae	+	+	
Commelina benghalensis Linn.	Kane jhar	Day flower	Commelinaceae	+	+	
Chenopodium album	Bethe	Lambsquater	Chenopodiaceae	+	+	+
Cannabis sativa	Ganja	Hemp	Cannabaceae	+		
Amaranthus spinosus	Kande lude	Spiny pigweed	Amaranthaceae	+	+	+
Solanum nigrum	Kali gedi	Black night shade	Solanaceae	+	+	
Anagallis arvensis	Nilo jhar	Scarlet pimpernel	Primulaceae	+		

4. CONCLUSION

The influence of tillage and weed management methods on yield and yield components of maize was determined. On the aspect of tillage, winter maize can be successfully grown under no till system provided the insure irrigation facilities in the humid sub tropics.Yield attribute character and yield was significantly influenced by different herbicidal application. Sequential application of atrazine and 2,4-D gave superior result on yield attributing traits, whereas herbicidal tank application gave comparatively lower values. Comparatively greater yield (5.18 t/ha) was also found in sequential application of atrazine and 2,4-D. Regarding yield of maize, treatment with black polythene mulching resulted in best grain yield. Besides the environmental protection, cowpea co-culture treatments yielded almost similar grain yield as compared with common herbicidal weed management practices.Grain yield found in cowpea co-culture treatments which are statistically similar with herbicidal application. The research is mostly focused on effectiveness of different weed control methods under conventional and no tillage system. In this aspect, future research can be conducted based on physical, chemical and biological properties of soil.Environment friendly black plastic mulching and cowpea intercropping methods along with herbicides were studied in this research and result showed positive on yield. Inspite of effectiveness in this study, recommendation of black plastic mulching as a best method to farmers in-depth study on cost benefit analysis of these weed control measures is required.

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