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ORIGINAL RESEARCH ARTICLE

# Effect of different weed management practices on production of spring maize in Dang, Nepal

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**ABSTRACT**

The study was carried out at Lamahi-8, Satbariya, Dang to evaluate the effect of different weed management practices on the production of spring maize. The experiment was carried out in a Randomized Complete Block Design using three replications and seven treatments. Rampur hybrid 10 variety and early post emergence (EPoE) herbicide were used in the experiment. The treatment consisted of single as well as combined weed management methods as $T_1$: Broadcasting-One hand weeding, $T_2$: Broadcasting-Herbicide, $T_3$: Line sown- One hand weeding, $T_4$: Line sown-Herbicide + one hand weeding, $T_5$: Line sown- Mini tiller weeder, $T_6$: Line sown- herbicide + mini tiller and $T_7$: Line sown- One hand weeding + mini tiller. The experiment result showed that the combined application of early post emergence herbicide and mini tiller resulted the highest grain yield (8.62 Mt/ha) with minimum total weed density at 60 DAS (41.33/$m^2$) and at harvest (68/$m^2$) thus resulting minimum weed dry weight at 60 DAS (5.45 g/$m^2$) and at harvest (10.64 g/$m^2$). Sixteen different weed species belonging to 9 different families were identified in the experimental field. The highest benefit: cost (3.37) was obtained in the treatment Line sown-Herbicide + mini tiller weeder which was significantly higher compared to other treatments. Among the treatments applied, one with the application of herbicide in combination with mini tiller weeder was found to be the most effective one that resulted in the minimum weed density and minimum dry weight, higher grain and biological yield with the highest benefit cost ratio thus proving to be the most economical one. At the same time, application of mini tiller weeder as a single method was found to be the next better alternative for weed control in spring maize that could benefit the farmers in comparison to other single weed management practices.



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## INTRODUCTION

Maize (*Zea mays* L) is the second predominant cereal crop of Nepal with a national production of 2,71,3635 Mt cultivated under an area of 956,447 ha with the productivity of 2.84 Mt/ha (MoALD, 2021). Maize is known as queen of cereals having the highest genetic yield potential among the cereals. Maize crop alone has the contribution of about 25.02% to total cereal production, 6.88% in Agriculture GDP and 3.15% in Gross Domestic Product (Dhakal *et al*., 2022). Dang district is the emerging hub for maize production with growing commercialization and mechanization towards sustainable and self-reliant agriculture (Khanal *et al*., 2019). In Dang district, most of the maize area is occupied by hybrid maize varieties mainly during the growing season of spring and winter (Khanal *et al*., 2019). The total area under maize production in Dang district during 2020/21 is 24,305 ha with the production total of 77,999 Mt (MoALD, 2021).

In Nepal, maize is mainly grown in sub-tropical to cool temperate climates and mainly cultivated for food, feed, and fodder purpose (Thapa, 2021). Though the large population depends on maize production as staple food, its demand is increasing rapidly due to expansion of poultry and feed industries in Nepal (Ghimire *et al*., 2018). The national production of maize is not enough to meet the human demand of country even if the maize is not used for animal feed (Guragain, 2019) The increment in feed demand lies at the rate of 11% per annum indicating shifting of maize demand from food to feed for livestock and poultry (KC *et al*., 2015). Despite the tremendous potentiality for its marketing, the increase in maize production is not being able to meet the higher pace of demand growth. There is a huge gap between the demand and production level of maize (Shrestha *et al*., 2019).

Weeds harbor insects, pests, and diseases along with their direct impact on yield reduction (Shrestha *et al*., 2019). The extent of maize yield loss due to weeds depends on cultivars, species, and number of weeds per unit area, crop-weed competition period and duration (Sharma *et al*., 2018). Competition imposed by different weeds is a major problem in spring maize (Singh *et al*., 2018). The severity of weed interference resulting in yield loss in maize depends upon the intensity, nature, stage and duration of weed interference (Singh *et al*., 2018). Weed can result reduction in the grain yield of spring maize by 37.17% (Shrivastav *et al*., 2015). The critical period of weed control in maize ranges between 2 to 6 weeks after sowing and during this period the maize plants are more sensitive to the competition imposed by weedy plants (Shrestha *et al*., 2019). Early growth stage of maize being more susceptible to weed competition demands efficient control at the pre and early post emergence stages (Shrestha *et al*., 2018). There exists a direct relationship between reduction in crop yield and weed competition (Marahatta, 2018). Manual, mechanical, and chemical methods are the major weed control measures practiced in maize cultivation (Shrestha *et al*., 2019). Weed management using chemical as pre and post emergence herbicide results cost effective weed control during the critical period of crop weed interference compared to higher cost incurring methods manual and mechanical (Triveni *et al*., 2017).

Farmers in Dang valley despite having access to the high-yielding hybrid varieties of maize still fail to attain maximum productivity of maize variety. Weed interference is one of the major reasons behind these which demands the need of finding sustainable and economic weed management practice. To prevent yield loss greater than 5%, maize crop needs to be maintained weed from V1 to V12 stage as critical period for weed control (CPWC) (Tursun *et al*., 2016). The farmers in Dang mostly rely on mechanical weed control measures however, still fail to attain complete weed control because of some disadvantages in the part of minitiller application. The use of mini tiller weeder as mechanical means for weed management to the full extent of efficiency is possible when the crop reaches knee high stage and by this time sufficient weed is found to be grown infesting the crop with the retarding impact in crop growth and development. On the other hand, early use of mini tiller results in crop injuries when applied at early stages when the crop is at shorter height. Canada thistle (*Cirsium arvense)* and other perennial weeds highly infest the spring maize for which mechanical method like mini tiller weeder has low efficacy for their control. Thus, this necessitates the study to be carried out to find the ways by which the efficiency of minitiller weeder could be increased either as a single method or in combination with herbicide and manual labor. The emergence of perennial weeds in early phase of crop demands numerous mechanical weeding which proves less economical for farmers. At the same time, higher cost of manual labor along with inadequacy of labor in time demands identification of cheaper weed control methods. Nevertheless, farmers are less inclined to apply pre-emergence herbicide around the time of sowing and considering it this research made the use of early post emergence herbicide rather than pre-emergence. Thus, this study was carried out to find the effective and more economic weed control method in spring maize using both single and combined weed management methods.

## MATERIALS AND METHODS

### Site selection

The research was conducted at Lamahi 8, Satbariya in Dang district in Rapti zone of southwestern Nepal. It has tropical climate and lies on the geographical coordinates of 27° 52'58" N 82° 25'36" E at 230 masl. The experiment was carried out from February 22 to June 20 2022. The soil type in the study site was found to be sandy loam (sand: 52.5%, silt: 43.4%, clay: 4.1%), slightly acidic (6.3 pH) with low content of organic matter (1.42%), low N (0.07%), low P (15.46 kg/ha), low K (15.23 kg/ha).

### Field preparation

The field was ploughed one month before seed sowing with the help of tractor to bring soil under good tilth condition. Before seed sowing breaking of soil clods and planking of the land was done after removing the remains of weeds and stubbles of the previous crop.

### Experimental design

The experiment was laid out in one factorial RCBD design with three replications consisting 7 treatments allocated randomly in each replication with individual plot size of 4×3 sqm.

Treatment details:

T1: Broadcasting-One hand weeding
T2: Broadcasting- Herbicide
T3: Line sown- One hand weeding
T4: Line sown- Herbicide + one hand weeding
T5: Line sown- Mini tiller weeder
T6: Line sown- Herbicide + mini tiller weeder
T7: Line sown- One hand weeding + mini tiller weeder

One hand weeding as a single management method and application of herbicide was done at 30 DAS. Treatment with mini tiller weeder and hand weeding in combination was carried out at 45 DAS. Herbicide namely mesozine which was the combination of atrazine 50% and mesotrine 5%SC (suspension concentrate) was used in the field. The composition of the herbicide included 55% active constituents, 10.6% surfactants and 34.4% solvents or inerts. The recommended dose for the application of herbicide was 1500-2250 ml/ha. Two methods were used for maize sowing- broadcasting and line sowing and the seed rate used in both lines sown and broadcasted maize was 30 kg/ha. Line sowing was carried out using a jab planter and time required while maize sowing and treatment application was recorded for the cost calculation for each plot.

### Observation

Data on biometric observation for plant height at 75 DAS was taken from randomly selected 5 central plants and phenological observation was made on days to 75 % silking, tasseling and physiological maturity. From the experimental site, 7.2 $m^2$ at the center was taken as the net harvest area. Yield attributing characters for cob length, number of kernels per row, 1000 grain weight, shelling percentage, grain and stover yield were recorded during the experimentation. Major weeds in the maize field were identified and observation on weed density and dry weight was made at 60 DAS and at harvest from the quadrate size of 0.5m×0.5m followed by oven drying of weed at 72°C for 3 days till constant weight was obtained. For the benefit cost analysis, cost of cultivation, gross return and net return were recorded and finally benefit cost ratio was calculated. The cost of cultivation was calculated based on local charges for different agro-inputs viz., labor, fertilizer, herbicide, machines, and other necessary materials.

The shelling percentage was calculated using a formula (Bista *et al*., 2021).

$$\text{Shelling percentage} = \frac{\text{Grain weight}}{\text{cobweight}} * 100$$

The grain yield was computed for each treatment from net plot area. Final yield was calculated at 14% moisture content using the formula (Bista *et al*., 2021).

$$\text{Grain yield (Mt ha}^{-1}) = \frac{\text{FEW} * \text{SP} * (100 - \text{GMC})}{\text{NHA} * 86 * 10}$$

Where,

FEW = field ears weight (Kg)

SP = shelling percentage (%)

GMC = grain moisture content at harvest (%)

NHA = net harvested area ($m^2$)

B:C ratio was calculated by the following formulae (Qahar and Ahmad, 2016).

$$\text{B: C ratio} = \frac{\text{Gross return}}{\text{Total cost of cultivation}}$$

The data recorded on different parameters from field and laboratory were first tabulated in Microsoft Excel (MS- Excel). Then, Analysis of Variance (ANOVA) for all data was statistically analyzed using R- STUDIO - computer software package. All the analyzed data were subjected to Duncan's Multiple Range Test (DMRT) for mean comparison at 5% level of significance.

## RESULTS AND DISCUSSION

Weed management practice showed a significant influence on plant height and phenological attributes viz. days to silking, days to tasseling and days to physiological maturity (Table 1). Significantly higher plant height at 75 DAS was observed under the treatment Line sown: Herbicide + minitiller (170.27cm). The result was found statistically at par with the treatment Line sown: minitiller weeder (159.10cm). The result showed the significant effect of weed management practices on days to tasseling, silking, and physiological maturity. Significantly shortest period to tasseling (69 days) was observed under the treatment Line sown: Herbicide + mini tiller which was statistically at par with the treatment Line sown: Minitiller weeder. While the longest period to tasseling (73.67 days) was observed under the treatment Broadcasting: One hand weeding which was at par with treatment Broadcasting: Herbicide. Significantly shortest period to silking (70.67 days) was observed under the treatment Line sown: Herbicide + mini tiller while the longest period to silking (77.33 days) was observed under Broadcasting: One hand weeding. The result also showed the significant effect of weed management practices on days to physiological maturity. The minimum days to physiological maturity (106 days) was observed under the treatment Line sown: Herbicide + mini tiller while the highest (111.67days) was recorded under Broadcasting: One hand weeding. The highest plant height and minimum days to tasseling, silking, and physiological maturity was obtained under the combined weed management practice compared to single practice which could be due to minimum crop-weed competition imposed throughout growth period of maize resulting in optimum utilization of nutrient, light, and moisture.

The yield attributing characters were found to be significantly influenced by weed management practices (Table 2). The longest cob length of 16.70 cm was measured for treatment Line sown: Herbicide + minitiller which was significantly higher among all. The shortest cob length of 12.65 cm was measured under the treatment Broadcasting: One hand weeding. Shrestha *et al.* (2019) also reported the highest cob length (18.77 cm) under the combined weed management practice as manual weeding + herbicide compared to single weed management practice. The highest number of kernels per row (28.24) was obtained in Line sown: Herbicide + one hand weeding followed by treatment Line sown: Herbicide + mini tiller which was statistically similar with single weed management treatment as Line sown: Minitiller weeder.

The maximum thousand grain weight (322.70g) was obtained under treatment Line sown: Minitiller weeder which was

**Table 1.** Plant height and phenological observation as influenced by weed management practices in spring maize in Dang, Nepal, 2022.

| Treatment | Plant height (75DAS) cm | Days to tasseling | Days to silking | Days to physiological maturity |
|---|---|---|---|---|
| Broadcasting: One hand weeding | 93.67$^{d}$ | 73.67$^{a}$ | 77.33$^{a}$ | 111.67$^{a}$ |
| Broadcasting: Herbicide | 110.47$^{cd}$ | 72.33$^{ab}$ | 75.33$^{ab}$ | 110.33$^{ab}$ |
| Line sown: One hand weeding | 124.97$^{bcd}$ | 71b$^{c}$ | 73.67$^{bc}$ | 108.67$^{bc}$ |
| Line sown: Herbicide + one hand weeding | 132.73$^{abc}$ | 71b$^{c}$ | 74.00$^{bc}$ | 109.67$^{ab}$ |
| Line sown: Minitiller weeder | 159.10$^{ab}$ | 69$^{d}$ | 72.00$^{cd}$ | 107$^{cd}$ |
| Line sown: Herbicide + mini tiller | 170.27$^{a}$ | 69$^{d}$ | 70.67$^{d}$ | 106$^{d}$ |
| Line sown: One hand weeding + mini tiller | 141.23$^{ab}$ | 69.67$^{cd}$ | 72.33$^{cd}$ | 107.33$^{cd}$ |
| LSD (0.05) | 36.54 | 1.83 | 2.22 | 2.04 |
| SEm ± | 4.48 | 0.23 | 0.27 | 0.25 |
| F-test | ** | ** | ** | ** |
| CV, % | 15.42 | 1.46 | 1.69 | 1.06 |
| Grand mean | 133.21 | 70.81 | 73.62 | 108.67 |

DAS = Days after sowing, Means followed by the same letter(s) in a column are not significantly different by DMRT at 5% level of significance. ns = non-significant, *=significant at 5% probability level, **= significant at 1% probability level.

**Table 2.** Yield attributing characters as influenced by weed management practice in spring maize in Dang, Nepal, 2022.

| Treatment | Cob length (cm) | No. of kernels per row | Test weight (g) | Sterility % | Shelling % | Yield (Mt/ha) | Stover yield (Mt/ha) | Harvest Index |
|---|---|---|---|---|---|---|---|---|
| Broadcasting: One hand weeding | 12.65$^{c}$ | 18.13$^{c}$ | 267.34$^{d}$ | 18.17$^{ab}$ | 64.79$^{b}$ | 3.84$^{d}$ | 5.78$^{c}$ | 0.40$^{c}$ |
| Broadcasting: Herbicide | 14.15$^{b}$ | 21.13$^{b}$ | 286.31$^{cd}$ | 18.62$^{ab}$ | 71.94$^{ab}$ | 6.47$^{bc}$ | 6.30$^{bc}$ | 0.51$^{ab}$ |
| Line sown: One hand weeding | 16.23$^{a}$ | 26.59$^{a}$ | 293.28$^{bcd}$ | 20.16$^{a}$ | 65.38$^{b}$ | 5.75$^{c}$ | 6.81$^{bc}$ | 0.46$^{b}$ |
| Line sown: Herbicide + one hand weeding | 16.65$^{a}$ | 28.24$^{a}$ | 307.83$^{abc}$ | 13.61$^{bc}$ | 73.47$^{ab}$ | 7.96$^{a}$ | 7.07$^{abc}$ | 0.53$^{a}$ |
| Line sown: Minitiller weeder | 16.32$^{a}$ | 27.05$^{a}$ | 322.70$^{a}$ | 15.08$^{abc}$ | 76.35$^{a}$ | 7.69$^{ab}$ | 7.53$^{ab}$ | 0.51$^{ab}$ |
| Line sown: Herbicide + mini tiller | 16.70$^{a}$ | 27.98$^{a}$ | 320.00$^{ab}$ | 10.22$^{c}$ | 80.90$^{a}$ | 8.62$^{a}$ | 8.30$^{a}$ | 0.51$^{ab}$ |
| Line sown: One hand weeding + mini tiller | 16.5$^{a}$ | 27.66$^{a}$ | 315.97$^{ab}$ | 16.59$^{ab}$ | 78.26$^{a}$ | 7.93$^{a}$ | 7.07$^{abc}$ | 0.53$^{a}$ |
| LSD (0.05) | 0.68 | 2.08 | 24.68 | 5.13 | 8.45 | 1.25 | 1.36 | 0.05 |
| SEm ± | 0.083 | 0.25 | 3.23 | 0.63 | 1.04 | 0.15 | 0.04 | 0.007 |
| F-test | *** | ** | ** | * | ** | ** | * | ** |
| CV, % | 2.45 | 4.62 | 4.9 | 17.96 | 6.51 | 10.15 | 10.92 | 6.15 |
| Grand mean | 15.60 | 25.25 | 301.92 | 16.06 | 73.01 | 6.895 | 6.98 | 0.49 |

Means denoted by the same letter(s) in a column are not significantly different by DMRT at 5% level of significance. *= significant at 5% probability level, **= significant at 1% probability level, ***= significant at 0.1% probability level.

significantly higher among all other treatments and was statistically at par with the treatment Line sown: Herbicide + mini tiller (320 g) and treatment Line sown: One hand weeding + mini tiller (315.97 g). While the minimum thousand grain weight (267.34 g) for the treatment Broadcasting: One hand weeding was obtained which was statistically at par with Broadcasting: Herbicide. The sterility percentage was found to be minimum (10.22%) in the treatment Line sown: Herbicide + mini tiller while the highest sterility percentage was observed in treatment Line sown: One hand weeding. The average shelling percentage of spring maize obtained was 73.01% and was significantly influenced by different weed management practices. The shelling percentage was significantly higher (80.90%) in treatment Line sown: Herbicide + mini tiller among all other treatments which was at par with the treatment Line sown: Minitiller weeder. Shrestha *et al*. (2019) also reported the highest cob length (18.77 cm), highest grain yield (6.54 t/ha), stover weight (22.7 t/ha), harvest index (0.285), and maximum no. of kernels per row (31.83) with the lowest sterility percentage (18.66) under the combined weed management practice as manual weeding + herbicide compared to the single weed management practice.

Statistical analysis of data showed that the highest grain yield of 8.62 Mt/ha obtained under the treatment Line sown: Herbicide + mini tiller was significantly higher than all other treatments (Table 2). While among single weed management practice, the maximum yield of 7.69 Mt/ha was obtained in the treatment Line sown: Minitiller weeder and the lowest grain yield (3.84 Mt/ha) was attained under the treatment Broadcasting: One hand weeding followed by treatment Line sown: One hand weeding (5.75 Mt/ha). The result of mean data indicated that the variation in biological yield (Mt/ha) due to the influence of different weed management practices was found to be significant. The highest stover yield (8.30 Mt/ha) was produced under the treatment Line sown: Herbicide + mini tiller which was significantly higher than other treatments while statistically

**Table 3.** Weeds observed in experimental field in spring maize.

| Common name | Scientific name | Weed category | Family |
|---|---|---|---|
| Lamb's quarter | *Chenopodium album* (L.) | BLW | Amarantheacea |
| Marijuana | *Cannabis sativa* (L.) | BLW | Cannabaceae |
| Canada Thistle | *Cirsium arvense* (L.) | BLW | Asteraceae |
| Mustard | *Brassica juncea* (L.) | BLW | Brassicaceae |
| Whitetop weed | *Parthenium hysterophorus* (L.) | BLW | Asteraceae |
| Common cockle bur | *Xanthium strumarium* (L.) | BLW | Asteraceae |
| False amaranth | *Digera arvensis* (L.) | BLW | Amaranthaceae |
| Black nightshade | *Solanum nigrum* (L.) | BLW | Solanaceae |
| Goatweed | *Ageratum conyzoides* (L.) | BLW | Asteraceae |
| Snake cucumber | *Cucumis melo* (L.) | BLW | Cucurbitaceae |
| Wild gooseberry | *Physalis minima* (L.) | BLW | Solanaceae |
| Red spurge | *Euphorbia hirta* (L) | BLW | Euphorbiaceae |
| Bermuda grass | *Cynodon dactylon* (L.) | GW | Poaceae |
| Crowfoot grass | *Dactyloctenium aegyptium* (L.) | GW | Poaceae |
| Para grass | *Brachiaria reptans* (L.) | GW | Poaceae |
| Purple nutsedge | *Cyperus rotundus* (L.) | SW | Cyperaceae |

**Table 4.** Weed density and weed dry weight as influenced by weed management practices in spring maize in Dang, Nepal, 2022.

| Treatment | Total weed density (no./m$^2$) | | Total weed dry weight (g/m$^2$) | |
|---|---|---|---|---|
| | 60 DAS | At harvest | 60 DAS | At harvest |
| Broadcasting: One hand weeding | 15.08$^{a}$ (229.3) | 12.60$^{ab}$ (158.67) | 5.53$^{a}$ (30.46) | 6.36$^{a}$ (40.03) |
| Broadcasting: Herbicide | 10.49$^{bc}$ (110.67) | 8.95$^{c}$ (80) | 3.78$^{b}$ (13.87) | 3.92$^{c}$ (14.91) |
| Line sown: One hand weeding | 13.73$^{ab}$ (190.67) | 13.40$^{a}$ (181.33) | 4.99$^{a}$ (24.74) | 6.08$^{ab}$ (36.72) |
| Line sown: Herbicide + one hand weeding | 8.06$^{cd}$ (70.67) | 10.13$^{bc}$ (105.33) | 2.56$^{c}$ (6.49) | 4.70$^{bc}$ (22.03) |
| Line sown: Minitiller weeder | 8.50$^{cd}$ (73.33) | 9.53$^{bc}$ (92) | 3.02$^{bc}$ (8.80) | 4.16$^{c}$ (17.51) |
| Line sown: Herbicide + mini tiller | 6.41$^{d}$ (41.33) | 7.90$^{c}$ (68) | 2.44$^{c}$ (5.45) | 3.19$^{c}$ (10.64) |
| Line sown: Hand weeding + mini tiller | 9.33$^{cd}$ (89.33) | 10.71$^{abc}$ (114.67) | 2.77$^{bc}$ (7.48) | 4.71$^{bc}$ (22.46) |
| LSD(0.05) | 3.65 | 2.95 | 1.11 | 1.44 |
| SEm ± | 0.45 | 0.36 | 0.14 | 0.47 |
| F-test | ** | * | *** | ** |
| CV,% | 20.09 | 15.85 | 17.39 | 17.10 |
| Grand mean | 10.23 | 10.46 | 3.58 | 4.73 |

Means followed by the same letter(s) in a column are not significantly different by DMRT at 5% level of significance. ns = Non significant, **=significant at 1% probability level, GW= grassy weeds, SW= sedge weeds, BLW= Broad leaf weeds; Data are subjected to square root transformation ( $\sqrt{(x+0.5)}$ and data on parentheses are original values.

similar to the treatment Line sown: Minitiller weeder (7.53 Mt/ha) and the lowest stover yield (5.78 Mt/ha) was produced under the treatment Broadcasting: One hand weeding. Among the treatments applied, the herbicide application followed by minitiller weeder recorded the highest grain yield and stover yield of spring maize The lowest grain yield of spring maize was found under single weed management practice of hand weeding that might be the consequence of stiff competition imposed by weeds resulting poor yield attributing characters. Fang *et al.* (2022) also observed synergized effect of combined mechanical and chemical weeding in maize that was proved advantageous for crop growth; the study showed better grain number per year, 1000 grain weight and yield compared to the chemical application only. While single mechanical weeding treatment was found to be better in producing higher yield only.

Sixteen different weed species belonging to 9 different families were identified in the experimental field (Table 3). *Chenopodium album*, *Cannabis sativa*, *Parthenium hysterophorus*, *Cynodon dactylon*, *Dactyloctenium aegyptium*, *Brachiaria reptans* and *Cyperus rotundus* were the major weed species identified in the research field (Table 3). (Ram *et al.*, 2017) carried out a field study on maize and the major weeds species namely; *Parthenium hysterophorus*, *Melilotus alba*, *Cyperus rotundus*, *Trianthema portulacastrum*, *Dactyloctenium aegyptium*, *Cynodon dactylon*,

**Table 5.** Costs and benefit of spring maize production as influenced by weed management practices.

| Treatment | Total cost of cultivation NRs (USD) | Gross return NRs (USD) | Net return NRs (USD) | B:C ratio |
|---|---|---|---|---|
| Broadcasting: One hand weeding | 89596.27 ($680.93) | 132633.3$^{c}$ ($1008.01) | 43037.06$^{d}$ ($327.08) | 1.48$^{d}$ |
| Broadcasting: Herbicide | 82668.98 ($628.28) | 213088.9$^{b}$ ($1619.48) | 130419.91$^{bc}$ ($991.19) | 2.58$^{bc}$ |
| Line sown: One hand weeding | 84926.90 ($645.44) | 193044.4$^{b}$ ($1467.14) | 108117.54$^{c}$ ($821.69) | 2.27$^{c}$ |
| Line sown: Herbicide + one hand weeding | 85780.23 ($651.93) | 259922$^{a}$ ($1975.41) | 174141.99$^{a}$($1323.48) | 3.03$^{ab}$ |
| Line sown: Mini tiller weeder | 85426.90 ($649.24) | 253183$^{a}$ ($1924.19) | 167756.43$^{ab}$ ($1274.95) | 2.96$^{ab}$ |
| Line sown: Herbicide + mini tiller | 84196.90 ($639.90) | 283388.9$^{a}$ ($2153.6) | 199191.99$^{a}$ ($1513.85) | 3.37$^{a}$ |
| Line sown: Hand weeding + mini tiller | 92843.57 ($705.61) | 259208.3$^{a}$ ($1969.98) | 166364.76$^{ab}$ ($1264.37) | 2.79$^{b}$ |
| LSD (0.05) | _ | 39370.63 | 40358.95 | 0.47 |
| SEm ± | _ | 4829.35 | 4950.58 | 0.058 |
| F-test | _ | *** | *** | *** |
| CV, % | _ | 9.72 | 16.06 | 9.99 |
| Grand mean | 86491.39 | 227781.3 | 141290 | 2.64 |

Note: Means denoted by the same letter(s) in a column are not significantly different by DMRT at 5% level of significance. ***= significant at 0.1% probability level. NRS= Nepali Rupees. The local market price of maize grain was 30Rs/Kg ($0.228/kg) and stover was assumed to be 3 Rs/Kg. Values inside parenthesis are given in USD.

*Digera muricata*, *Amaranthus viridis*, *Commelina benghalensis*, *Eragrostis cilianensis*, *Chenopodium album*, *Trichodesma indicum*, *Digitaria sanguinalis*, *Euphorbia geneculata and Echinochloa colona* were found comprising of 49% broadleaved weeds, 44% grasses and 7% sedges. Dahal and Karki (2014) also reported 12 major species of weed including *Cynodon dactylon*, *Digitaria ciliaris*, *Cyperus rotundus*, *Ageratum conyzoides* etc. in spring maize in Rampur, Chitwan. The study showed that the spring maize is majorly infested by broadleaf weeds and grasses in comparison to sedges weeds from the stage of emergence to harvesting.

The result showed the significant influence of weed management practices on total weed count and total weed dry weight at 60 DAS and at harvest (Table 4). At 60 DAS, the minimum total weed density (41.33/$m^2$) was observed under the treatment Line sowing: Herbicide + mini tiller which was significantly lower among all other treatments. The maximum weed density (229.3/$m^2$) was observed under the treatment Broadcasting: One hand weeding which was significantly higher among all other treatments and statistically similar to the treatment Line sowing: One hand weeding (190.67/$m^2$). At harvest, the minimum total weed density (68/$m^2$) was observed under the treatment Line sown: Herbicide + mini tiller which was significantly lower among all other treatments and was statistically similar to the treatments Line sown: Minitiller weeder (92/$m^2$). At 60 DAS and at harvest the minimum total weed dry weight of 5.45g/$m^2$ and 10.64 g/$m^2$ respectively were measured under the treatment Line sown: Herbicide + mini tiller. While the maximum total weed dry weight (40.03 g/$m^2$) was obtained under treatment Broadcasting: One hand weeding which was significantly higher among all other treatments and was statistically similar to the treatment Line sowing: One hand weeding (36.72 g/$m^2$). The combined weed management method of herbicide followed by minitiller resulted the minimum weed density and weed dry weight that enabled crop to take more nutrients resulting improved growth of crop as an effective weed control method and reduction in the crop weed competition.

The cost of production and return was calculated for one hectare from the cost involved in the experimental plots (Table 5). The maximum cost of cultivation (NRs 92843.57/705.61 USD) was incurred under the treatment Line sown: One hand weeding + minitiller which was due to requirement of higher number of labour and high labor cost. The minimum cost of cultivation (NRs 82668.98/628.28 USD) incurred in Broadcasting: Herbicide. The highest net return 199191.99/1513.85 USD) was obtained under treatment Line sown: Herbicide + mini tiller while the minimum net return (Nrs 43037.06/327.08 USD) was obtained under treatment Broadcasting: One hand weeding. Among different weed management practices, the highest B:C ratio of 3.37 was obtained under treatment Line sown: Herbicide + mini tiller while among the single weed management practices, the highest B:C ratio of 2.96 was obtained under treatment Line sown: Minitiller weeder (Table 5). The lowest B:C ratio (1.48) was obtained under the treatment Broadcasting: One hand weeding. Higher grain yield and stover yield might have been responsible for the corresponding higher net returns of experimented weed management practices thus resulting higher benefit cost ratio.

## Conclusion

Based on the results obtained by the field experiment it can be concluded that the combined application of early post emergence herbicide followed by minitiller weeder as a weed management method in spring maize results beneficial effect on biometric and yield attributes. Comparatively, the combined weed management practice is more effective one over other single method thus resulting maximum weed control with minimum weed density and weed dry weight. Similarly, among all combined application of early post emergence herbicide followed by minitiller resulted maximum reduction of weed population and dry weight as well. Although the cost of cultivation with the combined treatment was higher compared to

some single treatments, the combined one resulted higher economic and biological yield with higher B:C ratio. The efficiency of mini tiller weeder could be increased when applied after the application of early post emergence herbicide that could result in reduced weed growth and improved grain and biological yield. Application of early post emergence herbicide over pre or post emergence herbicide can be made to obtain effective weed control in spring maize by farmers. The combined application of early post emergence herbicide followed by minitiller could be the innovative measure for the maize farmers who either skip the pre-emergence herbicidal application or could not afford the labor-intensive hand weeding. Also, the application of mini tiller weeder as a single weed control method could be a better alternative as well for controlling weed growth with higher return.

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