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# Phenology of Maize (*Zea Mays* L.) and Associated Weeds as Influenced by Tillage and Weed Control Methods under Mid-Hill Conditions of North West Himalayas

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**Abstract :** *A field study was conducted on silty clay loam soils to study the effect of tillage and weed control methods on phenology of maize and associated weeds and their influence on the production of crop. The results revealed that irrespective of tillage and weed control methods, Digitaria sanguinalis, Echinochloa colona and Panicum dichotomiflorum and sedge (Cyperus iria) emerged earlier by 4-8 days than maize crop resulting more competition in the initial stages of growth. Commelina benghalensis emerged and senescenced almost along with the crop. While all other weeds flowered at tasseling stage of the maize crop, Echinochloa colona and Panicum dichotomiflorum flowered 7-8 days earlier to this stage. Senescence of almost all the weeds except Commelina benghalensis occurred 15-25 days earlier than the maize crop. Zero tillage resulted in significantly early emergence of the crop by 4-5 days over other tillage methods but the emergence of grass weeds was not affected significantly. Appearance of all the phenophases of the crop and associated weeds was initiated early in zero till plots as compared to raised seed bed and conventional tilled plots resulting in reduction in grain yield of maize by 13.7 and 16.9 per cent over raised seed bed and conventional tillage. Effective control of weeds with atrazine 1.5 kg/ha and acetachlor 1.25 kg/ha delayed the emergence and appearance of different phenophases of weeds than the crop resulting in 75.2 and 71.7 per cent average increase in grain yield of maize, respectively over unweeded check.*

**Keywords:** Acetachlor, Atrazine, Emergence, Raised seedbed, Senescence, Zero tillage, Phenology.

## Introduction

Maize is one of the major cereal crops of Himachal Pradesh and is highly invaded by a number of weed species which cause 28-100 per cent yield loss (Angiras and Singh, 1989). Comparative studies of growth and development of weeds and crops are essential in order to quantify, predict and manage crop yield losses caused by weeds (Cousens *et al*., 1992). Phenological prediction would allow more accurate estimates of the timing and effects of weed competition on crop yield in particular agronomic systems and thus allow more specific control measures to be developed (Ritchie, 1991). Thus the success of weed management based on ecological principles and weed biology will depend on a better understanding of the effect of environment on growth and competition of weeds and crops and particularly upon the ability to predict weed and crop phenology (Ghersa and Holt, 1995). The tillage methods influences the vertical distribution of weed seeds in soil layer, affecting weed seed germination rates, survival of weeds and their phenology, thus, affecting weed dynamics through alteration of environment which, favours certain weed cycle over others (Buhler, 1995). Also, the manipulation of soil environment by tillage influences the growth and development of the crop, its phenology and competitiveness against weeds. Different weed control methods create variable microenviron-

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ment by suppressing growth of some weed species and encouraging others thus making difference in their phenology and competitive ability with the crop. Therefore the present study was undertaken to study the influence of tillage and weed control methods on phenology of maize and associated weeds and consequently their influence on productivity of maize under mid hill conditions of North West Himalayas.

## Materials and Methods

A field experiment was conducted under rainfed conditions at the research farm of Department of Agronomy, CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during *kharif* seasons of *2002* and 2003. The soil of the experimental field was silty clay loam in texture, acidic in reaction (pH 5.6) and medium in available nitrogen, potassium and phosphorus (302.8, 17.8 and 316.7 kg $ha^{-1}$ during first year and 296.6, 18.6 and 321.9 kg $ha^{-1}$ during second year, respectively). A total of 914.2 mm and 1820.0 mm rainfall was received during the life cycle of the crop in first and second year, respectively. The experiment was laid in split plot design by keeping three tillage methods *viz*. zero tillage, conventional tillage and raised seed bed in main plots and four weed control methods *viz.* unweeded check, acetachlor 0.75 and 1.25 kg/ha and atrazine 1.5 kg/ha in sub plot and replicated thrice. The gross plot size of each sub plot was 5.0 m x 3.6 m and net plot size was 4.6 m x 2.4 m. The certified seeds of maize hybrid variety PSCL-3438 were sown on 11 June during both the years with all recommended package of practices except treatments of tillage and weed control methods. The sowing in zero tillage and raised seed bed plots was done with zero tillage maize planter and raised seed bed planter, respectively. All the herbicide treatments were applied immediately after sowing with Maruyama Power Sprayer as per the treatments using 600 liters of water per hectare. The crop was harvested on 27$^{th}$ and 24$^{th}$ September during 2002 and 2003, respectively.

The phenology of the crop and associated weeds was recorded in all the treatments as per following procedure:

### Phenology of weeds

In each plot a sampling area of 50 cm x 50 cm was demarcated at random with the help of quadrate. Since it is very difficult to identify the small emerging plants of *D. sanguinalis, E. colona* and *P. dichotomiflorum*, the observation taken for days to emergence was collective for all these weeds and expressed in a single value and separate for *C. benghalensis*. The observation was taken at every alternate day after sowing of the crop till almost constant count of the emerged weeds was obtained.

To record the days taken to flowering and senescence of weeds five plants of each weed species were tagged in each plot at random and observed at every alternate day after the appearance of the first flower till complete flowering. Similarly these plants were observed for their senescence. The dates on which all the tagged plants of each of the weed species attained flowering and senescence was recorded and used for calculating number of days taken to flowering and senescence of different weed species, respectively.

Data on total weed count and weed dry matter at maximum dry matter stage (*i.e.* 60 DAS) was recorded from the sampling quadrate area. The data thus obtained was converted to per square meter and subjected to square root transformation for statistical analysis.

### Phenology of maize

One meter sampling area was earmarked randomly at two places in each of the plot immediately after sowing. The emergence count was recorded daily from the sampling area in each plot from the date of appearance of first seedling till it was constant and number of days taken to emergence were calculated from the date of sowing. Similarly, the treatment plots were visited every alternate day from the date of

first appearance of tassel and silk till 50 per cent tasseling and silking. The dates on which half of the 10 tagged plants in net plot showed tasseling or silking were recorded and used for calculating number of days taken for 50 per cent tasseling and silking, respectively from the date of sowing. Similarly, number of days taken to maturity were calculated from the date when the cob sheaths of almost all the tagged maize plants in each net plot turned brownish yellow, started drying and the grains get hardened**.**

The data on grain and stover yield of the crop were recorded after harvesting, decobing and shelling of the produce of the net plot area.

## Results and Discussion

### Weed Flora

The major weeds of the experimental field were *Digitaria sanguinalis, Echinochloa colona, Panicum dichotomiflorum, Brachiaria ramosa, Commelina benghalensis and Cyperus iria. Among these D. sanguinalis, E. colona, P. dichotomiflorum and B. ramosa constituted* 87.9 and 69.06 per cent of the total weed flora during first and second year, respectively. However per cent proportion constituted by *Commelina benghalensis* was 5.23 and 17.13 during first and second year, respectively. *Cyperus iria* was the only sedge present in the experimental area constituted 3.27 and 6.35 per cent of the total weed flora in the respective years. The *Oxalis latifolia*, *Ageratum conyzoides Cynodon dactylon, Ipomoea purpurea*, *Polygonum alatum* were also present in the experimental area and only constituted 3.60 and 7.46 per cent of the total weed flora during first and second year, respectively.

### Effect on phenology of weeds

### Emergence

In general *Digitaria sanguinalis, Echinochloa colona, Panicum dichotomiflorum* and *Cyperus iria* emerged earlier by 4-8 days than the maize crop resulting in more competition with the crop right from the initial stages of growth. Data presented in Table 1 revealed that tillage methods significantly influenced the emergence of *C. benghalensis* only. Zero tillage significantly delayed the emergence of *Commelina benghalensis* by 2-3 days over other tillage methods because of deep placement (35.4 mm) of its seeds/rhizomes in zero tillage plots as compared to plots with other tillage methods (29-32 mm).

Atrazine 1.5 kg $ha^{-1}$ being statistically at par with aceatchlor 1.25 kg $ha^{-1}$ delayed the emergence of *Digitaria sanguinalis, Echinochloa colona, Panicum dichotomiflorum* and *Commelina benghalensis* by 1-3 days over other methods of weed control because of effective control of their seeds present in the upper soil layers during both the years.

### Flowering and senescence

Raised seed bed and conventional tillage being statistically at par delayed the flowering of *Digitaria sanguinalis* and *Echinochloa colona* significantly except for *Commelina benghalensis* and *Cyperus iria* during both the years and *Panicum dichotomiflorum* during the second year (Table 2). These two tillage methods being statistically at par significantly delayed the senescence of *D. sanguinalis* and *P. dichotomiflorum*. However, raised seedbed was significantly superior over other tillage methods and was followed by conventional tillage in delaying the senescence of *C. benghalensis* by 2-15 days and *E. colona* by 2-4 days.

Weed control methods had no significant influence on flowering of *E. colona, P. dichotomiflorum, C. benghalensis* and *C. iria*. However, atrazine 1.5 kg/ha and acetachlor 1.25 kg/ha being statistically at par with each other significantly delayed the flowering of *D. sanguinalis* by 3-5 days over unweeded check during both the years. All the weed control methods significantly delayed the senescence of *D. sanguinalis* (3-6days) and *C. iria* (2-5 days) during both years and *C. benghalensis* (3-5 days) during second year of experimentation.

Table 1 Effect of tillage and weed control methods on days to emergence of *E. colona, D. sanguinalis, P. dichotomiflorum* and *C. benghalensis.*

| Treatments | *E. colona, D. sanguinalis* and *P. dichotomiflorum* | | *C. benghalensis* | |
|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 |
| Tillage methods | | | | |
| Zero | 7 | 6 | 15 | 14 |
| Conventional | 8 | 7 | 12 | 12 |
| Raised seed bed | 8 | 7 | 13 | 12 |
| LSD (P=0.05) | NS | NS | 2.0 | 2.0 |
| Weed control methods | | | | |
| Unweeded | 6 | 6 | 13 | 11 |
| Acetachlor 0.75 kg/ha | 7 | 6 | 12 | 12 |
| Acetachlor 1.25 kg/ha | 8 | 7 | 14 | 14 |
| Atrazine 1.5 kg/ha | 9 | 8 | 14 | 14 |
| CD (P=0.05) | 1.1 | 1.2 | 1.4 | 1.5 |

**Effect on phenology of crop**

Data in Table 3 revealed that tillage and weed control methods influenced the days taken to different phenophases of maize crop significantly during both the years. Among tillage methods, raised seedbed significantly delayed different phenophases over rest of the methods during both the years. However, conventional tillage was statistically at par with it to delay 50% tasseling, silking and maturity during the first year. Delay in emergence by 4-5 days over zero tillage in raised seedbed might be due to placement of maize seeds in relatively deeper depth as compared to relatively shallow placement of seed by zero tilled plots with presence of adequate moisture. Subsequent delay in appearance of reproductive phases of the crop in raised seed bed may be ascribed to prolonged vegetative phase of the crop due to increased uptake of nutrients and moisture because of better soil aeration and root development of the crop.

All the weed control treatments being statistically at par with each other significantly delayed the 50% tasseling during first year and 50 % silking and maturity during both the years and had no significant influence on emergence of crop during both years. The delay in attainment of reproductive phase of the crop could be ascribed to prolonged vegetative phase under low crop weed competition environment created by effective weed control treatments.

**Effect on weed count and dry matter of weeds**

Among various tillage methods raised seed bed resulted in significantly lowest dry matter and population of total weeds during both the years The superiority of raised seed bed to decrease population and dry matter of weeds could be ascribed to presence of significantly lowest number of weed seeds in its top 0-10 cm soil layer as compared to other tillage methods which helped the crop to take lead in its growth and establishment and suppressing the weeds growth due to less weed density.

Table 2 Effect of tillage and weed control methods on days taken to initiation of flowering and senescence of *E. colona, D. sanguinalis*, *P. dichotomiflorum*, *C. benghalensis* and *C. iria.*

| Treatments | *D. sanguinalis* | | | | *E. colona* | | | | *P. dichotomiflorum* | | | | *C. benghalensis* | | | | *C. iria* | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Flowering | | Senescence | | Flowering | | Senescence | | Flowering | | Senescence | | Flowering | | Senescence | | Flowering | | Senescence | |
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Tillage Methods | | | | | | | | | | | | | | | | | | | | |
| Zero | 52 | 50 | 88 | 78 | 43 | 47 | 79 | 83 | 44 | 47 | 82 | 75 | 60 | 58 | 86 | 83 | 51 | 57 | 80 | 84 |
| Conventional | 58 | 54 | 92 | 82 | 47 | 50 | 81 | 84 | 49 | 50 | 84 | 78 | 60 | 59 | 97 | 85 | 52 | 58 | 82 | 83 |
| Raised seed bed | 58 | 55 | 91 | 82 | 46 | 50 | 83 | 86 | 49 | 50 | 84 | 79 | 61 | 59 | 101 | 87 | 52 | 59 | 84 | 84 |
| LSD (P=0.05) | 1.6 | 3.9 | 3.4 | 2.0 | 2.3 | 2.2 | 1.0 | 1.7 | 2.0 | NS | 0.6 | 2.1 | NS | NS | 3.6 | 1.5 | NS | NS | NS | NS |
| Weed Control Methods | | | | | | | | | | | | | | | | | | | | |
| Unweeded | 54 | 51 | 88 | 76 | 45 | 48 | 80 | 83 | 46 | 47 | 81 | 76 | 59 | 57 | 95 | 82 | 50 | 56 | 80 | 81 |
| Acetachlor 0.75 kg/ha | 55 | 52 | 91 | 79 | 45 | 48 | 81 | 84 | 47 | 49 | 83 | 78 | 60 | 58 | 95 | 85 | 52 | 58 | 83 | 83 |
| Acetachlor 1.25 kg/ha | 58 | 54 | 91 | 82 | 46 | 50 | 81 | 83 | 48 | 50 | 81 | 78 | 61 | 59 | 95 | 86 | 53 | 59 | 82 | 85 |
| Atrazine 1.5 kg/ha | 59 | 54 | 92 | 82 | 46 | 49 | 82 | 86 | 48 | 49 | 80 | 79 | 61 | 59 | 97 | 87 | 52 | 58 | 84 | 86 |
| CD (P=0.05) | 2.3 | 2.3 | 2.7 | 2.0 | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | NS | 2.3 | NS | NS | 2.4 | 1.8 |

Table 3 Effect of tillage and weed control methods on days taken to emergence, 50% tasseling, 50% silking and maturity of maize crop.

| Treatments | Emergence | | 50% Tasseling | | 50% Silking | | Maturity | |
|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 |
| Tillage methods | | | | | | | | |
| Zero | 11 | 11 | 55 | 54 | 62 | 60 | 100 | 101 |
| Conventional | 14 | 13 | 58 | 54 | 65 | 61 | 103 | 102 |
| Raised seed bed | 16 | 15 | 59 | 59 | 67 | 65 | 105 | 104 |
| CD (P=0.05) | 0.8 | 1.6 | 2.4 | 4.2 | 3.0 | 2.9 | 3.3 | 2.2 |
| Weed control methods | | | | | | | | |
| Unweeded | 13 | 13 | 55 | 54 | 61 | 59 | 100 | 99 |
| Acetachlor 0.75 kg/ha | 13 | 13 | 58 | 56 | 65 | 63 | 104 | 103 |
| Acetachlor 1.25 kg/ha | 13 | 13 | 59 | 57 | 66 | 62 | 104 | 104 |
| Atrazine 1.5 kg/ha | 13 | 13 | 58 | 56 | 65 | 64 | 103 | 103 |
| CD (P=0.05) | NS | NS | 1.2 | NS | 1.9 | 2.9 | 1.5 | 3.0 |

Among various weed control methods atrazine 1.5 kg $ha^{-1}$ being statistically at par with acetachlor 1.25 kg $ha^{-1}$ were significantly superior over other weed control methods in reducing the total population and dry matter of weeds during both the years. Results of Sharma *et al*. (2000) and Petrychenko *et al.* (2005) also reported the superiority of atrazine and acetachlor, respectively to control weeds in maize.

**Effect on grain and Stover yield**

It is evident from the Table 4 that conventional tillage being statistically at par with raised seed bed significantly increased the grain and stover yield of maize over zero tillage during both the years. The percent increase in grain yield due to conventional tillage and raised seed bed was 17.2 and 13.2 percent, respectively during first year and 16.6 and 14.2 percent, respectively during second year. These results are in direct conformity with the findings of Subbulakshmi *et al*. (2009) for superiority of conventional tillage and of Fausey (1990) for superiority of raised seed bed over zero tillage.

All the weed control methods were significantly superior to unweeded check in increasing grain and stover yield of maize significantly during both the years. Among weed control methods atrazine 1.5 kg $ha^{-1}$ and acetachlor 1.25 kg $ha^{-1}$ being statistically at par with each other produced significantly higher grain and stover yield of maize during both the years. Atrazine 1.5 kg $ha^{-1}$ and acetachlor 1.25 kg $ha^{-1}$ increased the grain yield by 72.2 and 72.0 percent, respectively over unweeded check during first year and by 78.2 and 71.4 per cent, respectively during second year by their effective control of weeds because of late emergence of weeds, reducing crop-weed competition and thus prolonging all the phenophases of the crop under competition free environment.

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Table 4 Effect of tillage and weed control methods on total weed count (No./$m^2$), total weed dry matter (g/$m^2$), grain and stover yield (kg/ha) of maize.

| Treatments | Total weed count (No./$m^2$) | | Total weed dry matter (g/$m^2$) | | Grain yield (kg/ha) | | | Stover yield (kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2002 | 2003 | 2002 | 2003 | Mean | 2002 | 2003 | Mean |
| Tillage methods | | | | | | | | | | |
| Zero | 13.8 (206.0) | 16.5 (283.3) | 10.0 (112.6) | 11.4 (139.4) | 5862 | 5736 | 5799 | 12634 | 11993 | 12313 |
| Conventional | 13.1 (186.0) | 16.1 (270.0) | 9.2 (94.6) | 11.1 (131.3) | 6872 | 6687 | 6779 | 14697 | 14152 | 14425 |
| Raised seed bed | 12.4 (164.3) | 15.3 (241.0) | 8.1 (73.7) | 9.8 (107.3) | 6638 | 6552 | 6595 | 14120 | 13927 | 14023 |
| CD (P=0.05) | 0.7 | 0.5 | 0.4 | 0.3 | 236 | 446 | 341 | 1144 | 474 | 809 |
| Weed Control Methods | | | | | | | | | | |
| Unweeded | 19.4 (377.3) | 21.2 (447.1) | 14.8 (219.0) | 16.3 (265.3) | 4379 | 4172 | 4275 | 9259 | 8705 | 8982 |
| Acetachlor 0.75 kg/ha | 12.9 (165.8) | 16.2 (260.0) | 8.7 (75.5) | 10.8 (115.8) | 6383 | 6542 | 6463 | 13529 | 13775 | 13652 |
| Acetachlor 1.25 kg/ha | 10.3 (104.9) | 13.5 (180.9) | 6.7 (42.8) | 8.1 (63.8) | 7527 | 7152 | 7340 | 16133 | 15190 | 15661 |
| Atrazine 1.5 kg/ha | 9.8 (93.8) | 13.2 (171.1) | 6.2 (31.2) | 7.8 (59.0) | 7541 | 7433 | 7487 | 16347 | 15760 | 16053 |
| CD (P=0.05) | 0.6 | 0.6 | 0.5 | 0.3 | 312 | 289 | 301 | 752 | 587 | 669 |

Values in parentheses are means of original values

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