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# Effect of Time and Method of Post-Emergence Atrazine Application in Controlling Weeds in Maize

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***ABSTRACT: Fifteen weed control treatments comprising of atrazine 1.5 & 2.0 kg/ha as spray and broadcast with sand on 7, 14 and 21 days after sowing (DAS); atrazine 1.5 kg/ha pre-emergence spray; farmer's practice and weedy check were tested during kharif 2013 on a silty clay loam soil at Palampur. Echinochloa colona, Commelina benghalensis, Ageratum conyzoides, Cyperus sp., Digitaria sangunalis and Panicum dichotomiflorum were the important weeds. Grassy weeds were more pre-dominant than broad-leaf weeds. Pre-emergence spray of atrazine 1.5 kg/ha and spray of atrazine 2 kg/ha on 7 DAS were effective in controlling grassy weeds but weeds that appear late during crop growth i.e Ageratum conyzoides and Cyperus sp. were better controlled by spray of atrazine 2 kg/ha on 21 DAS. Atrazine 2 kg/ha applied on 7 DAS (spray) remaining at par with Atrazine 1.5 kg/ha applied on 7 DAS (spray), Atrazine 1.5 kg/ha applied on 14 DAS (spray), Atrazine 2 kg/ha applied on 14 DAS (spray), Atrazine 1.5 kg/ha applied on 21 DAS (spray), Atrazine 2 kg/ha applied on 21 DAS (spray) and Atrazine 1.5 kg/ha (pre- emergence spray) gave significant higher grain yield over rest of the treatments. Net returns over weedy control/check were higher under atrazine 2.0 kg/ha sprayed on 7 DAS followed by pre-emergence application of atrazine (1.50 kg/ha). Marginal benefit cost ratio was highest under pre-emergence atrazine at 1.5 kg/ha followed by atrazine 1.5 kg/ha sprayed on 7 DAS.***

***Keywords: atrazine, doses, application methods, maize***

## Introduction

Maize has attained a commercial crop status due to easiness in cultivation, free from pest and diseases, high yield and better market price. There is lot of scope to increase maize yield. The yield can be increased with many agronomic manipulations. Management of weeds is an important factor for achieving higher productivity. Presence of weeds reduces the photosynthetic efficiency, dry matter production and distribution to economical parts and there by reduces sink capacity of crop resulting in

 

poor grain yield. Yield losses due to season long weed infestation range from 30 per cent to complete crop failure (Rana et al. 1998; Pandey et al. 2001; Kumar et al. 2012). The choice of weed control measures largely depend on its effectiveness and economics. Due to increased cost and non availability of manual labour for hand weeding, herbicides are preferred. Atrazine is a broad-window and broad-spectrum selective herbicide recommended for the control of weeds in maize. Atrazine as pre or early post-emergence is widely used for broadleaf and grassy weed control in maize. Its application as pre-emergence is well established. In certain areas, farmers are facing difficulty in spraying herbicides because of labour shortage and scarcity of water particularly during the critical stages of crop growth. The application of some herbicides along with sand as broadcast was found effective in some of the crops (Sharma et al. 2000). Moreover, the acceptability of herbicide by the growers as pre-emergence is very poor and generally the post-emergence applied herbicides are preferred. Therefore, the post-emergence application of atrazine by different methods *viz.*, spray or mixed with sand was felt essential. Hence, the present investigation was undertaken to work out the efficacy of dose, time and method of application of atrazine in maize.

## Materials and Methods

The field experiment was conducted at Palampur ($32^0$.6' N latitude, $76^0$.3' E longitudes and 1290.8 meters altitude) during *kharif* 2013. Agro-climatically Palampur falls under the sub temperate humid zone of Himachal Pradesh which is characterized by mild summers and cool winters. The soil of the test site was silty clay loam in texture, medium in organic carbon, low in N and K and medium in P and acidic in reaction. Fifteen weed control comprising of atrazine 1.5 and 2 kg/ha as spray and broadcast with sand on 7th, 14th and 21th DAS;; atrazine 1.5 kg/ha pre-emergence; farmer's practice and weedy check (Table 1) were tested in randomized block design with 3 replications. The seeds of 'Kanchan Hybrid 717' were sown on June 17, 2013 in lines at plant-to-plant distance of 20 cm and row-to-row distance of 60 cm. N, $P_2O_5$ and $K_2O$ at 120, 60 and 40 kg/ha were applied through urea (46% N), single super phosphate (16% $P_2O_5$) and muriate of potash (60% $K_2O$), respectively. One- third nitrogen and whole $P_2O_5$ and $K_2O$ were applied at the time of sowing. The required fertilizer quantity was mixed thoroughly and then placed in open furrows. Remaining nitrogen was applied in two splits each at knee high and tasseling stage. Pre and post-emergence application of atrazine 1.5 and 2 kg as per the treatment using 750 litres of water per hectare was done with the help of manually operated power sprayer and with

 

sand at 150 kg/ha. Hand weeding and earthing up was done at 30 DAS in treatment 'farmer's practice' with the help of a local tool called "khunti". The maize crop was harvested on October 5, 2013 when the cob sheath turned brown and the grains were hard.

The species-wise weed count was recorded at 30, 60, 90 DAS and at harvest. Yield and yield attributes were recorded at harvest. Economics of the treatments was computed based on prevalent market prices.

**Results and Discussion**

*Echinochloa colona* and *Commelina benghalensis* were the major weeds constituting 22.6 and 20.7 per cent, respectively of total weed population. *Ageratum conizoides, Cyperus sp., Digitaria sanguinalis* and *Panicum dichotomiflorum* constituted 16.0, 14.1, 14.5 and 12.2 per cent, respectively, of total weed population,.

**Weed count**

The data on weed count have been recorded at 30, 60, 90 DAS and at harvest. The count of all weeds in general except *Ageratum conyzoides* and *Cyperus sp.* was maximum at 60 DAS (maximum count of *Ageratum conyzoides and Cyperus sp.* was at 90 DAS) and gradually decreased thereafter (data not shown), probably owing to intra and inter-specific competition. Table 1 shows the data on weed count at maximum population stage *i.e.* 60 DAS. The count of *Echinochloa colona* was in general higher at 60 DAS and decreased slightly thereafter. All treatments were significantly superior to weedy check in reducing the count of *Echinochloa colona*. Atrazine 2 kg/ha applied on 7 DAS (spray) remaining at par with Atrazine 1.5 kg/ha (pre-emergence spray) resulted in significantly lower count of *Echinochloa colona* at 60 DAS than other treatments. The superiority of atrazine in controlling *Echinochloa colona* has been reported (Rana et al 1998; Kumar et al. 2012). Atrazine 1.5 kg/ha (pre-emergence) being at par with Atrazine 2 kg/ha applied on 7 DAS (spray) significantly reduced the population of *Commelina benghalensis* at 60 DAS. The other treatments were also superior to weedy check. Similar results have also been shown by Saini and Angiras (1998) and Kumar et al. (2012). Weed control treatments significantly influenced the population of *Ageratum conyzoides* at all

 

stages of observation. Atrazine 2 kg/ha applied on 21 DAS (spray) remaining at par with atrazine 1.5 kg/ha applied on 21 DAS (spray) and Atrazine 2 kg/ha applied on 21 DAS (broadcasting with sand) resulted in significantly lower count of *Ageratum conyzoides* at 60 DAS. As *Ageratum conyzoides* appeared late, so atrazine application on 21 DAS was most effective (Kumar et al. 2012). Weed control treatments also significantly influenced the population of *Cyperus sp*. at all the stages of observation. There was complete elimination of the population of *Cyperus sp*. under Atrazine 2 kg/ha applied on 21 DAS (spray). This is in conformity with the finding of Khan and Haq (2004). All weed control treatments were significantly superior to weedy check in reducing the population of *Digitaria sanguinalis*. The population of *Digitaria sanguinalis* was completely eliminated under Atrazine 2 kg/ha applied on 7 DAS (spray) and Atrazine 1.5 kg/ha (pre- emergence). This result was in conformity with finding of Sharma et al. (2000). *Panicum dichotomiflorum L*. was completely killed under Atrazine 2 kg/ha applied on 7 DAS (spray) and Atrazine 1.5 kg/ha (pre- emergence). The present results corroborated with the findings of Saini (2000). The population of *Panicum dichotomiflorum* was highest in weedy check throughout the crop growth. Weed control treatments significantly influenced the total weed count. Owing to reduction in species-wise weed count, all weed control treatments gave significant reduction in total weed count as compared to weedy check (Table 1 & Fig 1). Atrazine 1.5 kg/ha pre- emergence) and Atrazine 2 kg/ha applied on 7 DAS (spray) at 60 DAS resulted in significantly lower total weed count over other treatments. Reduction in weed density with the application of atrazine was reported by Patel et al. (2000), Kumar et al. (2012) and Rana et al. (1998).

**Yield attributes and Yield**

The data on yield attributes and yield have been given in Table 2. Weed control treatments brought about significantly variation in effective plant population. Atrazine 2 kg/ha aaplied on 7 DAS (spray), Atrazine 1.5 kg/ha on 7 DAS (spray), Atrazine 2 kg/ha broadcast with sand on 7 DAS, Atrazine 1.5 kg/ha spray on 14 DAS and Atrazine 1.5 kg/ha (pre-emergence

 

spray) had higher effective plant population over other treatments. Number of cobs per plant were not significantly affected due to weed control treatments. Similarly, test weight is a genetic character and was not significantly influenced due to weed control treatments. The shelling percentage of maize was significantly affected due to different weed control treatments. The weed control treatments significantly affected the number of grains per cob of maize. Atrazine 1.5 kg/ha applied on 14 DAS (spray) had significantly higher number of grains per cob and was statistically at par with Atrazine 1.5 kg/ha applied on 7 DAS (spray), Atrazine 2 kg/ha applied on 7 DAS (spray), Atrazine 2 kg/ha applied on 14 DAS (spray), Atrazine 1.5 kg/ha applied on 21 DAS (spray), Atrazine 2 kg/ha applied on 21 DAS (spray) and Atrazine 1.5 kg/ha (pre-emergence spray). There was decrease in number of grains per cob with increase in weed competition (Rana et al. 1998; Kumar et al 2012). Due to variation in effective plant population, grains/cob and shelling percentage, the grain yield of maize was significantly varied under weed control treatments (Table 2). All the weed control treatments except Farmer's practice were significantly superior to weedy check in increasing the grain yield of maize. Atrazine 2 kg/ha applied on 7 DAS (spray) remaining at par with Atrazine 1.5 kg/ha applied on 7 DAS (spray), Atrazine 1.5 kg/ha applied on 14 DAS (spray), Atrazine 2 kg/ha applied on 14 DAS (spray), Atrazine 1.5 kg/ha applied on 21 DAS (spray), Atrazine 2 kg/ha applied on 21 DAS (spray) and Atrazine 1.5 kg/ha (pre- emergence) gave significant higher grain yield over rest of the treatments. It was mainly due to minimum crop-weed competition throughout the crop growth period, thus enabling the crop for maximum utilization of resources which influenced growth and yield components. In weedy check, severe crop weed competition resulted in poor source and sink development with poor yield components. Weeds in weedy check reduced the grain yield of maize by 57.5 per cent over the best treatment.

 

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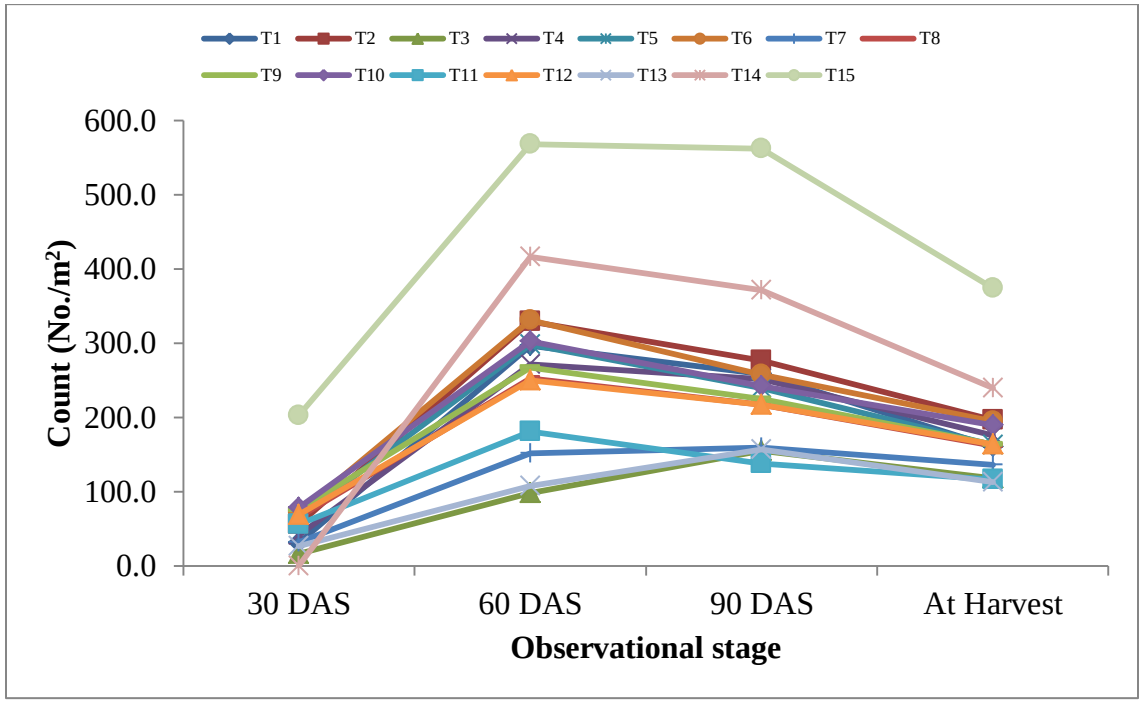


**Fig. 1.** Effect of treatments on progressive count (No./$m^2$) of weeds (total)

 

**Table 1** Effect of treatments on species-wise weed density (No./$m^2$) at maximum weed population stage *i.e.* 60 DAS

| Treatment | Dose (kg/ha) | TOA (DAS) | *Echinochloa colona* | *Commelina benghalensis* | *Ageratum conyzoides* | *Cyperus sp.* | *Digiteria sanguinalis* | *Panicum dichotomiflorum* | *Total weed count* |
|---|---|---|---|---|---|---|---|---|---|
| Atrazine | 1.5 | 7 (spray) | 9.0 (80.5) | 7.7 (58.7) | 7.0 (48.0) | 6.8 (44.8) | 5.9 (34.1) | 5.5 (29.9) | 16.4 (266.7) |
| Atrazine | 1.5 | 7 (Bc) | 9.6 (90.7) | 8.0 (62.4) | 7.1 (50.1) | 7.1 (50.1) | 6.3 (38.4) | 6.2 (37.30 | 17.1 (291.3) |
| Atrazine | 2 | 7 (spray) | 6.2 (37.3) | 4.1 (16.0) | 5.2 (26.7) | 4.4 (18.1) | 1.0 (0.0) | 1.0 (0.0) | 11.1 (123.0) |
| Atrazine | 2 | 7 (Bc) | 8.1 (65.8) | 7.0 (48.0) | 6.1 (36.3) | 7.0 (48.0) | 6.2 (37.3) | 6.0 (35.7) | 16.8 (282.7) |
| Atrazine | 1.5 | 14 (spray) | 9.3 (85.3) | 8.1 (65.1) | 6.5 (41.3) | 6.6 (42.7) | 6.0 (34.7) | 5.5 (28.9) | 15.9 (252.9) |
| Atrazine | 1.5 | 14 (Bc) | 10.0 (98.7) | 8.5 (72.0) | 6.7 (44.3) | 6.8 (44.8) | 6.5 (41.6) | 5.7 (32.0) | 15.9 (250.7) |
| Atrazine | 2 | 14 (spray) | 7.4 (53.3) | 5.7 (32.0) | 5.4 (28.8) | 1.0 (0.0) | 4.7 (21.3) | 5.3 (28.9) | 12.5 (154.9) |
| Atrazine | 2 | 14 (Bc) | 8.5 (70.8) | 7.3 (52.3) | 5.7 (31.5) | 6.4 (40.5) | 6.3 (38.4) | 5.5 (32.0) | 15.8 (247.6) |
| Atrazine | 1.5 | 21 (spray) | 9.4 (86.9) | 8.7 (74.7) | 4.5 (19.2) | 4.9 (23.5) | 6.2 (37.3) | 4.7 (26.9) | 15.4 (236.8) |
| Atrazine | 1.5 | 21 (Bc) | 9.6 (92.0) | 9.0 (80.0) | 4.9 (23.5) | 5.7 (32.0) | 6.6 (42.7) | 5.7 (28.9) | 15.2 (230.7) |
| Atrazine | 2 | 21 (spray) | 8.4 (69.3) | 6.8 (45.9) | 4.1 (16.0) | 1.0 (0.0) | 5.7 (32.0) | 4.2 (21.3) | 13.5 (181.3) |
| Atrazine | 2 | 21 (Bc) | 9.0 (80.0) | 7.9 (61.9) | 4.8 (22.4) | 4.1 (16.0) | 6.5 (40.9) | 5.7 (32.0) | 14.9 (222.2) |
| Atrazine | 1.5 | PE | 6.6 (42.7) | 4.1 (16.0) | 5.3 (27.7) | 4.7 (21.3) | 1.0 (0.0) | 1.0 (0.0) | 11.1 (122.7) |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Farmer's practice | - | 30 | 10.6 (112.0) | 9.8 (96.0) | 7.0 (48.0) | 8.1 (64.0) | 7.0 (48.0) | 6.6 (42.7) | 19.6 (384.0) |
| Weedy check | - | - | 11.6 (133.3) | 11.1 (122.7) | 10.1 (101.3) | 9.3 (85.3) | 9.1 (82.1) | 8.8 (76.8) | 23.8 (567.1) |
| CD (P=0.05) | - | - | 0.7 | 0.6 | 0.7 | 0.7 | 0.6 | 0.9 | 0.47 |

Data transformed to square root transformation ($\sqrt{x+1}$), Values given in parenthesis are the means of original values, TOA: Time of application, Bc: Broadcast with sand, PE: Pre-emergence, DAS: Days after sowing

 

**Table 2.** Effect of treatments on yield attributes and yield of maize

| Treatment | Dose (kg/ha) | TOA (DAS) | Effective plant population/$m^2$ | Cobs/ plant | Grains/cob | Shelling per centage | Test weight (g) | Grain yield (kg/ha) |
|---|---|---|---|---|---|---|---|---|
| Atrazine | 1.5 | 7 (spray) | 8.3 | 1.1 | 388.2 | 79.8 | 205.8 | 4398 |
| Atrazine | 1.5 | 7 (Bc) | 7.8 | 1.1 | 352.7 | 80.2 | 230.0 | 3472 |
| Atrazine | 2 | 7 (spray) | 8.3 | 1.2 | 392.5 | 82.3 | 238.3 | 4630 |
| Atrazine | 2 | 7 (Bc) | 7.9 | 1.0 | 336.7 | 78.7 | 220.0 | 3588 |
| Atrazine | 1.5 | 14 (spray) | 8.1 | 1.2 | 397.9 | 82.0 | 230.0 | 4167 |
| Atrazine | 1.5 | 14 (Bc) | 7.5 | 1.0 | 350.9 | 79.5 | 222.1 | 3588 |
| Atrazine | 2 | 14 (spray) | 8.0 | 1.1 | 388.7 | 81.9 | 235.0 | 3935 |
| Atrazine | 2 | 14 (Bc) | 7.6 | 1.0 | 351.7 | 77.9 | 201.5 | 3241 |
| Atrazine | 1.5 | 21 (spray) | 8.1 | 1.1 | 378.4 | 80.9 | 225.4 | 3819 |
| Atrazine | 1.5 | 21 (Bc) | 7.5 | 1.1 | 338.3 | 78.1 | 212.7 | 3472 |
| Atrazine | 2 | 21 (spray) | 8.1 | 1.1 | 388.2 | 81.3 | 226.3 | 3935 |
| Atrazine | 2 | 21 (Bc) | 7.6 | 1.1 | 348.2 | 78.9 | 215.2 | 3472 |
| Atrazine | 1.5 | PE | 8.3 | 1.1 | 373.6 | 81.5 | 228.1 | 4514 |
| Farmer's practice | - | 30 | 7.6 | 1.0 | 352.7 | 78.3 | 206.4 | 2778 |
| Weedy check | - | - | 7.0 | 1.0 | 272.6 | 73.6 | 205.0 | 1968 |
| CD (0.05) | - | - | 0.4 | NS | 38.6 | 2.6 | NS | 924 |

TOA: Time of application, Bc: Broadcast with sand, PE: Pre-emergence, DAS: Days after sowing

**Economics**

A perusal of data (Table 3) revealed that control of weeds under different weed control treatments increased the gross returns over weedy check**.** Gross and net return over weed control were highest in Atrazine 2 kg/ha applied on 7 DAS (spray) followed by Atrazine 1.5 kg/ha (pre-emergence). Marginal benefit cost ratio was highest in Atrazine 1.5 kg/ha (pre-emergence) followed by Atrazine 1.5 kg/ha applied on 7 DAS (spray), Atrazine 1.5 kg/ha spray on 14 DAS and Atrazine 2 kg/ha spray on 7 DAS. The superior performance of above treatments was ascribed to higher grain and stover yield of maize and comparatively lower cost of weed control. Lower net returns under weedy check were due to lower grain and stover yield. This result was in conformity with Rana et al (1998) and Kumar et al. (2012).

**Table 3.** Economic of treatments

| Treatment | Dose (kg/ha) | TOA (DAS) | Gross returns (`/ha ) | Cost of weed control (`/ha) | Gross returns over control (`/ha) | Net returns over control (`/ha) | Marginal benefit cost ratio |
|---|---|---|---|---|---|---|---|
| Atrazine | 1.5 | 7 (spray) | 64873 | 1800 | 35851 | 34051 | 18.9 |
| Atrazine | 1.5 | 7 (Bc) | 51215 | 2400 | 22193 | 19793 | 8.2 |
| Atrazine | 2 | 7 (spray) | 68287 | 2200 | 39265 | 37065 | 16.8 |
| Atrazine | 2 | 7 (Bc) | 52922 | 2800 | 23900 | 21100 | 7.5 |
| Atrazine | 1.5 | 14 (spray) | 61458 | 1800 | 32436 | 30636 | 17.0 |
| Atrazine | 1.5 | 14 (Bc) | 52922 | 2400 | 23900 | 21500 | 9.0 |
| Atrazine | 2 | 14 (spray) | 58044 | 2200 | 29022 | 26822 | 12.2 |
| Atrazine | 2 | 14 (Bc) | 47801 | 2800 | 18779 | 15979 | 5.7 |
| Atrazine | 1.5 | 21 (spray) | 56337 | 1800 | 27315 | 25515 | 14.2 |
| Atrazine | 1.5 | 21 (Bc) | 51215 | 2400 | 22193 | 19793 | 8.2 |
| Atrazine | 2 | 21 (spray) | 58044 | 2200 | 29022 | 26822 | 12.2 |
| Atrazine | 2 | 21 (Bc) | 51215 | 2800 | 22193 | 19393 | 6.9 |
| Atrazine | 1.5 | PE | 66580 | 1800 | 37558 | 35758 | 19.9 |

 

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|---|---|---|---|---|---|---|---|
| Farmer's practice | - | 30 | 40972 | 6000 | 11950 | 5950 | 1.0 |
| Weedy check | - | - | 29022 | 0 | 0 | 0 | - |

TOA: Time of application, Bc: Broadcast with sand, PE: Pre-emergence, DAS: Days after sowing

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