The Bioscan 12(1): 585-589, 2017 (Supplement on Agronomy)
AN INTERNATIONAL QUARTERLY JOURNAL OF LIFE SCIENCES
www.thebioscan.com

EFFECT OF HERBICIDES ON WEED DENSITY AND PRODUCTIVITY OF MAIZE

U. K. HULIHALLI, SHANTVEERAYYA AND C. B. KABADAGI
University of Agricultural Sciences, Dharwad – 580 005 ,Karnataka, INDIA
e-mail: hulihalliuk@uasd.in

KEYWORDS
Pre-emergence
post-emergence
weed control efficiency
weed index

Received on :
09.09.2016

Accepted on :
06.01.2017

***Corresponding author**

ABSTRACT

Field experiment was conducted during *Kharif* season of 2015-16 and 2016 -17 at the Main Agricultural Research Station, Dharwad, Karnataka to study the impact of herbicides on weed density and productivity of maize. Among the herbicide application treatments, application of Pendimethalin (1000 ml ha^{-1}) as pre emergence followed by Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as post emergence was resulted in effective control of grassy weeds at 50 DAS and at harvest (7.0 and 9.1, respectively) and satisfactory control of broad leaved weeds (1.81 and 4.3 at 50 DAS and at harvest, respectively) and sedges (3.6 at harvest), which was on par with Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as post emergence and Atrazine at 1.5 kg ha^{-1} as pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS. Higher grain yield(63.3 q ha^{-1}), stover yield (83.1 q ha^{-1}) test weight (28.5 g) and weed control efficiency (80.8 %) was achieved in sequential application of Pendimethalin (1000 ml ha^{-1}) as pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as post emergence application.

INTRODUCTION

Maize (*Zea mays* L.) is one of the most important cereal crop in the world agricultural economy both as food and fodder crop and is regarded as queen of cereals. Due to increased cost and non availability of manual labour in required quantity at right time for hand weeding, role of herbicide is significant preposition. Herbicides not only control the weeds timely and effectively but also offer great scope for minimizing the cost of weed control with irrespective of situation (Verma *et al.*, 2015). Use of pre and post-emergence application of herbicides would make herbicidal weed control more acceptable to farmers which will not change the existing agronomic practices but will allow for complete control of weeds. Usage of pre-emergence herbicides assumes greater importance in the view of their effectiveness from initial stages. Pre emergent application of herbicides will control the weeds up to 25 days and after that post emergent application is given so that further growth of weeds can also be controlled. Pre-emergence and post emergence herbicides will be an ideal means for controlling the weeds in view of economics and effectiveness in maize. Effective weed management is critical to maintaining agricultural productivity (Ahmed *et al*., 2010; Verma, 2014). By competing for light, water, space and nutrients, weeds can reduce crop yield and quality and can lead to billions of dollars in global crop losses annually (Das, 2008; Srinivasrao *et al*., 2014). Because of their ability to persist and spread through the multiple reproduction and dispersal of dormant seeds/ vegetative propagules, for this reason weeds are virtually impossible to eliminate from any given field (Singh, 2014; Sharma, 2014). Keeping the above facts in view, it was planned to take up a field experiment entitled "effect of herbicides on weed density and productivity of maize" with objectives of 1. To study the bio-efficacy of pre and post emergence sequential application of herbicides in maize. 2. To study the effect of pre and post emergence herbicides on weed population, weed dry weight and weed control efficiency. 3. To study the effect of pre and post emergence herbicides on yield parameters.

MATERIALS AND METHODS

A field experiment was conducted during *Kharif* season of 2015 and 2016 at the Main Agricultural Research Station, Dharwad, Karnataka situated at 15º 29′ N latitude, 74º 59′ E longitudes and at an altitude of 689 m above mean sea level. The experiment was laid out in RBD design with three replications having the treatments *viz*. T1: control (weedy check), T2: weed free, T3: Atrazine at 1.5 kg ha^{-1} pre emergence, T4: Atrazine (750 g ha^{-1}) + pendimethalin (750 ml ha^{-1}) pre emergence, T5: Atrazine (750 g ha^{-1}) fb 2,4 -D Amine (75%) at 25 days after sowing (DAS) as PoE, T6: Halosulfuron 60g ha^{-1} at 25 DAS, T7: Atrazine at 1.5 kg ha^{-1} pre emergence fb Halosulfuron 60 g ha^{-1} at 25 DAS, T8: Tembotrione 120 g ha^{-1} at 25 DAS, T9: Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE, T10: Atrazine at 1.5 kg ha^{-1} pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS. The soil of the experimental site was medium black clay with pH (6.89), EC (0.57 dS m^{-1}), organic carbon content was (0.58%), available N (275 kg ha^{-1}), P_2O_5 (18 kg ha^{-1}) and K_2O (325 kg ha^{-1}). The mean annual rainfall for the past 63 years at the Main Agricultural Research Station, Dharwad was 721 mm.

Nitrogen, phosphorous and potassium were applied at 100: 50: 25 N, P_2O_5 and K_2O kg ha^{-1} in the form of Urea, Di-ammonium Phosphate and Muriate of Potash. Pre-emergence applications of herbicides were sprayed uniformly after sowing of the crop (on the same day of sowing). The pre-emergence application was made on the soil surface uniformly by using 750 litres of spray solution ha^{-1} with minimum trampling (the soil has sufficient moisture at the time of herbicide spray). Post-emergence herbicides were applied uniformly on the weeds at 25 DAS. The number of weeds present in one m^2 area in each treatment was counted at 50 DAS and at harvest. These weeds were further classified into sedges, grasses and BLW and their population was recorded. Dry weight of weeds was recorded at harvest. The weeds were uprooted from the destructive sampling and were oven dried to a constant weight at 70 ºC and the dry weight of weeds was taken and expressed in g m^{-2}. Weed control efficiency was calculated on dry weight basis by adopting formula given by Mani *et al.* (1976).

$$\text{WCE}(\%) = \frac{\text{Dry weight ofweeds in weedy check(g)} - \text{Dry weight of weeds in the treatment in question(g)}}{\text{Dry weigth of weeds in weedy check(g)}}$$

Weed index is defined as the reduction in the yield due to presence of weeds in comparison with weed free check. Weed index was calculated by using the formula given by Gill and Vijay Kumar (1996).

$$\text{WI } (\%) = \frac{X - Y}{X} \times 100$$

Where, WI = Weed index, X = Maize yield from weed free plot, Y = Maize yield of the treatment plot in question.

The plant height was measured from base of the plant to the fully opened leaf until cob emergence and after tasseling upto the base of the collar of flag leaf and expressed in cm. At physiological maturity, the cobs were dehusked and harvested from each net plot. The harvested cobs were air dried, shelled, cleaned and weighed. Grain yield ha^{-1} was computed from yield per plot, which was expressed in q ha^{-1}. Straw yield was recorded after complete sun drying of stalks of each net plot and expressed in q ha^{-1}. The data collected from the experiment subjected to statistical analysis as described by Gomez and Gomez (1984). Further statistically analysed data were subjected to DMRT. The means followed by the same lower case letters did not differ significant.

RESULTS AND DISCUSSION

Important weed species observed in the experimental plot were *Cynodon dactylon*, *Digitaria marginata*, *Dinebra retroflexa*, *Echinochloa spp* and *Panicum spp*. While common broad leaved weeds were *Portulaca oleraceae, Phyllanthus niruri, Commelina benghalensis, Cyanotis cuccullata, Corchorous capsularis, Convolvulus arvensis, Parthenium hysterophorus* and *Euphorbia hirta*. The common sedge observed was *Cyperus rotundus*. Various earlier authors also reported different weed flora in maize (Mhlanga *et al.,* 2015; Saeed *et al.*, 2014; Pannacci and Tei, 2014; Chougala, 2013; and Ishrat, 2012).

The data on grassy, broad leaved and sedges weed density differed significantly due to various weed control treatments at 50 DAS and at harvest. The highest weed density was recorded with weedy check (6.2, 6.37 at 50 DAS and 6.56, 6.66, 4.62 at harvest, respectively), where as, weed free check recorded the lowest values (2.1, 1.21 at 50 DAS and 2.21, 1.47 at harvest, respectively) (Table 1), this was due to manual weeding and intercultivation carried out in these treatments which reduces the weed population. Similar results were observed by Birendra *et al.,* (2013). In weedy check, high density of weeds interfered the harvesting of maize. It was mainly due to uninterrupted growth of weeds which made best use of growth resources. Weed free check which received hand weeding at regular intervals, indicated that complete weed control was possible only by local methods (hand weeding). However, this will neither economical nor possible

Table 1: Effect of herbicides on weed population (pooled data of 2015 and 2016).

Treatment		Total number of weed at 50 DAS (m^{-2})		Total number of weed at harvest (m^{-2})		Sedges at harvest (m^{-2})
		Grass	BLW	Grass	BLW	
T1	control (weedy check)	*6.2 (38.4) ^{a}	*6.37 (40.1) ^{a}	*6.56 (42.6) ^{a}	6.66 (43.9) ^{a}	4.62 (20.9) ^{a}
T2	weed free	2.1 (4.1) ^{g}	1.21 (1.0) ^{f}	2.21 (4.5) ^{g}	1.47 (1.7) ^{f}	1.41 (1.5) ^{g}
T3	Atrazine at 1.5 kg ha^{-1} pre emergence	3.8 (14.0) ^{bc}	3.54 (12.1) ^{c}	4.10 (16.3) ^{bc}	3.96 (15.2) ^{c}	3.11(9.2) ^{b}
T4	Atrazine (750 g ha^{-1}) + pendimethalin (750 ml ha^{-1}) pre emergence	3.8 (13.9) ^{bc}	3.73 (13.5) ^{b}	4.08 (16.2) ^{bc}	4.18 (17.0) ^{b}	3.04 (8.8) ^{b}
T5	Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE	3.0 (8.8) ^{ef}	2.07 (3.8) ^{de}	3.29 (10.4) ^{ef}	2.47 (5.6) ^{de}	2.29 (4.8) ^{ef}
T6	Halosulfuron 60g ha^{-1} at 25 DAS	4.0 (15.6) ^{bc}	2.02 (3.6) ^{de}	4.31 (18.1) ^{b}	2.75 (7.1) ^{de}	3.16 (9.5) ^{b}
T7	Atrazine at 1.5 kg ha^{-1} pre emergence fb Halosulfuron 60 g ha^{-1} at 25 DAS	3.2 (9.7) ^{de}	2.02 (3.6) ^{de}	3.67 (13.0) ^{de}	2.69 (6.8) ^{de}	2.60 (6.3) ^{cd}
T8	Tembotrione 120 g ha^{-1} at 25 DAS	3.5 (11.6) ^{cd}	2.18 (4.3) ^{d}	3.79 (13.9) ^{cd}	2.63 (6.5) ^{de}	2.77 (7.2) ^{c}
T9	Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE	2.7 (7.0) ^{f}	1.81 (2.8) ^{e}	3.10 (9.1) ^{f}	2.19 (4.3) ^{e}	2.06 (3.8) ^{f}
T10	Atrazine at 1.5 kg ha^{-1} pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS	3.1 (9.3) ^{df}	1.88 (3.1) ^{de}	3.45 (11.5) ^{df}	2.52 (5.8) ^{de}	2.43 (5.5) ^{de}
S.Em +		0.13	0.1	0.12	0.1	0.1

DAS – Days after sowing, fb – followed by, PoE – Post emergence, BLW – Broad leaved weeds;*Transformed values:$\sqrt{X+0.5}$; Original Figures are given in parenthesis

Table 2: Effect of herbicides on weed dry weight, plant height, grain yield and stover yield (pooled data of 2015 and 2016).

Treatment		Dry weight at harvest (g m^{-2})			Plant height at harvest (cm)
		Grass	BLW	Sedges	
T1	control (weedy check)	*4.23 (17.4) [a]	*4.67 (21.3) [a]	*3.19 (9.7) [a]	170.7 [e]
T2	weed free	1.52 (1.9) [f]	1.59 (2.1) [f]	1.35 (1.3) [f]	213.3 [a]
T3	Atrazine at 1.5 kg ha^{-1} pre emergence	2.57 (6.1) [cd]	3.10 (9.1) [b]	1.95 (3.3) [bc]	187.7 [cd]
T4	Atrazine (750 g ha^{-1}) + pendimethal in (750 ml ha^{-1}) pre emergence	2.63 (6.4) [bc]	3.17 (9.5) [b]	1.99 (3.5) [b]	186.4 [cd]
T5	Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE	2.11 (3.9) [e]	2.21 (4.4) [de]	1.61 (2.1) [de]	204.2 [b]
T6	Halosulfuron 60g ha^{-1} at 25 DAS	2.73 (7.0) [b]	2.43 (5.4) [c]	2.04 (3.7) [b]	182.9 [d]
T7	Atrazine at 1.5 kg ha^{-1} pre emergence fb Halosulfuron 60 g ha^{-1} at 25 DAS	2.43 (5.4) [d]	2.32 (4.9) [cd]	1.74 (2.5) [d]	193.8 [cd]
T8	Tembotrione 120 g ha^{-1} at 25 DAS	2.50 (5.8) [cd]	2.34 (5.0) [cd]	1.87 (3.0) [c]	191.5 [cd]
T9	Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE	2.02 (3.6) [e]	2.09 (3.9) [e]	1.53 (1.9) [e]	208.6 [ab]
T10	Atrazine at 1.5 kg ha^{-1} pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS	2.17 (4.2) [e]	2.28 (4.7) [cd]	1.70 (2.4) [d]	202.4 [b]
S.Em +		0.07	0.05	0.04	2.84

DAS – Days after sowing, fb – followed by, PoE – Post emergence, BLW – Broad leaved weeds;*Transformed values:$\sqrt{X+0.5}$; Original Figures are given in parenthesis

Table 3: Effect of herbicides on weed control efficiency (WCE), weed index, 100-grain weight, grain yield, stover yield and harvest index (pooled data of 2015 and 2016).

Treatment		WCE (%)	Weed index (%)	100-grain weight (g)	Grain yield (q ha^{-1})	Stover yield (q ha^{-1})	Harvest index (%)
T1	control (weedy check)	0.0 [j]	22.3 [a]	20.5 [e]	51.0 [f]	71.0 [f]	41.8 [b]
T2	weed free	89.2 [a]	0.0 [f]	29.7 [a]	65.8 [a]	86.0 [a]	43.4 [a]
T3	Atrazine at 1.5 kg ha^{-1} pre emergence	61.6 [h]	16.6 [ac]	23.0 [d]	54.7 [df]	75.2 [df]	42.1 [ab]
T4	Atrazine (750 g ha^{-1}) + pendimethalin (750 ml ha^{-1}) pre emergence	59.8 [i]	17.1 [ac]	23.4 [d]	54.5 [df]	75.0 [df]	42.1 [ab]
T5	Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE	78.5 [c]	5.8 [df]	27.5 [ab]	61.9 [ac]	81.7 [ac]	43.1 [ab]
T6	Halosulfuron 60g ha^{-1} at 25 DAS	66.8 [g]	18.9 [ab]	22.3 [de]	53.2 [ef]	73.3 [ef]	42.0 [ab]
T7	Atrazine at 1.5 kg ha^{-1} pre emergence fb Halosulfuron 60 g ha^{-1} at 25 DAS	73.4 [e]	10.1 [ce]	24.5 [cd]	59.2 [bd]	79.0 [bd]	42.8 [ab]
T8	Tembotrione 120 g ha^{-1} at 25 DAS	71.7 [f]	13.3 [bd]	24.1 [cd]	57.1 [ce]	77.6 [ce]	42.4 [ab]
T9	Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE	80.8 [b]	3.7 [ef]	28.5 [a]	63.3 [ab]	83.1 [ab]	43.2 [ab]
T10	Atrazine at 1.5 kg ha^{-1} pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS	76.7 [d]	7.7 [df]	26.0 [bc]	60.8 [ac]	81.0 [bc]	42.8 [ab]
S.Em +		0.54	2.39	0.73	1.63	1.4	0.45

DAS – Days after sowing, fb – followed by, PoE – Post emergence, BLW – Broad leaved weeds

under scarcity of labour. This is in conformity with the findings of Kolage *et al*. (2004) and Patel *et al*. (2006).

Among the herbicide application treatments, application of Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as post emergence was resulted in effective control of grassy weeds (2.7 and 3.10 at 50 DAS and at harvest respectively) and satisfactory control of BLW (1.81, 2.19 at 50 DAS and at harvest respectively) and sedges (2.06) at harvest which was on par with Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as post emergence and Atrazine at 1.5 kg ha^{-1} pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS (Table 1). Application of atrazine and pendimethalin at one day after sowing noticed excellent control of weed population during initial stages of crop growth (grasses, sedges and broad leaved weeds) (Kolage *et al*., 2004). Application of 2, 4-D resulted in effective control of broad leaved weeds and satisfactory control of grasses and sedges (Ramesh and Nadanssababady, 2005). Variation of weeds in the chemically treated plots might have been difference in the mode of action of herbicides which significantly controlled the weeds in all the chemically control treatments. These results are in line with those reported by Roy *et al*. (2002), Skoko and Zivanovic (2002). They reported that there has been significant difference in weed density of various weed control practices and negatively affected the weed growth.

The dry weight of grassy, BLW and sedges also differed significantly due to various weed control treatments (Table 2). At harvest, the highest dry weight of grassy, BLW and sedges were recorded with weedy check (14.23, 4.67 and 3.19 g at harvest, respectively). It was mainly due to higher and luxurious growth of weeds *viz*. grasses, sedges and broad leaved which made best use of the growth resources. On the other hand, lower dry weight of grassy, BLW and sedges were recorded in weed free check (1.52, 1.59 and 1.35 g at harvest, respectively). This could be attributed to control of weeds by hand weeding at regular intervals, which resulted in reduced dry matter production by weeds.

Among the herbicide treatments, sequential application of Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE recorded significantly lower total dry weight of grassy, BLW and sedges (2.02, 2.09 and 1.53 g at harvest, respectively) and it was on par with Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE and Atrazine at 1.5 kg ha^{-1} pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS (Table 2). It was mainly due to the lowest population of broad leaved weeds and lower number of grasses and sedges. The data presented is in conformity with that of Kannur, (2008), Ramesh and Nadanssababady (2005).

Plant height reflects efficiency of the plant for photosynthetic radiation interception and vegetative growth character of crop plants in response of various applied inputs. Data regarding plant height was given in Table 2 which revealed that plant height was significantly affected by various weed control practices. The maximum plant height (213.3 cm) was recorded with weed free check which was statistically on par with Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE (208.6 cm) followed by Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE (204.2 cm) and Atrazine at 1.5 kg ha^{-1} pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS (202.4 cm). The variation in plant height of maize in all weed control treatments could be attributed to varying effect of weed competition duration for available resources offered by different weed densities in different weed control practices. These results are in line with Akhtar *et al*. (1998) and Hussain *et al*. (1998), who stated maximum plant height was in control plots.

Performance of crop is directly proportional to the weed control efficiency and inversely proportional to the weed index (Table 3). The minimum weed control efficiency was observed in weedy check (0.00%) whereas the highest (89.2 %) was recorded in a plot treated with hand weeding and hoeing *i.e.* weed free check. Among the herbicide treatments higher weed control efficiency was recorded with sequential application of Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE (80.8 %). The higher weed control efficiency with this treatment could be attributed to the lower weed population and total weed dry weight. But lower weed control efficiency among the herbicides was recorded with application of Atrazine (750 g ha^{-1}) + pendimethalin (750 ml ha^{-1}) as pre emergence (59.8 %). It was due to higher weed population and total dry weight of weeds in this treatment. These results corroborate with the findings of Saini and Angiras (1998). These results further indicates that herbicides are more effective in reducing density and dry weights of weeds next to weed free check as compared to weedy check. This result was in accordance with Mehmeti *et al*. (2012) who reported that herbicides reduced the weed infestation and control better in the maize crop in comparison to the control maize plots.

Weed index which is a measure of yield reduction due to weed competition, it was the highest with weedy check (22.3 %). This was due to lower maize grain yield in weedy check as a result of greater competition offered by unchecked weed growth for nutrients, moisture, space and light as indicated by poor growth and yield components (Krishnamurthy *et al*., 1981).

The lowest weed index (3.7%) was recorded with sequential application of Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE which was on par with Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE (5.8 %) and Atrazine at 1.5 kg ha^{-1} pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS (7.7 %). This was mainly due to the higher maize grain yields in these treatments as a result of improved growth and effective control of weeds there by reduction in the crop-weed competition. The results presented are in conformity with that of Kannur. (2008).

Apart from combined effect of all the other individual yield determining factors, the ultimate final grain yield of a cereal crop depends upon the 100-grain weight and seed development nourished under applied inputs and various weed control treatments. Any variation in the 100-grain yield will affect the grain yield. The maximum 100-grain weight (29.7 g) was attained with weed free check which was statistically at par with Pendimethalin (1000 ml ha^{-1}) pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE (28.5 g) and Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE (27.5 g). The significantly minimum 100-grain weight (20.5 g) was recorded in weedy check. Significantly higher test weight in weed control treatments than weedy check was due to vigorous growth and development of maize plants, which resulted in more photosynthates assimilation in grains thus more 100-grains weight. These results are in line with those of Hussain *et al.* (1998) and Bay and Bouchache (2007).

Grain yield is a function of the cumulative behavior among various yield determining components and it is the net result of various interactions *viz*. soil characters, weather parameters, crop-weed competition, leaf area and various metabolic and biochemical interactions taking place during crop growth. Maize grain yield is also influenced by dry matter accumulation in different parts especially in reproductive parts and yield components which is the product of interactions of above characters.

Yield of maize varied significantly among various weed control treatments (Table 3). The highest grain yield and stover yield of maize (65.8 and 86.0 q ha-1, respectively) was recorded with weed free check. It was mainly due to minimum crop-weed competition throughout the crop growth period, thus enabling the crop for maximum utilization of nutrients, moisture, light and space which had influence on growth components and yield components (Shinde *et al.,* 2001).

Among the herbicide application treatments, sequential application of Pendimethalin (1000 ml ha^{-1}) as pre emergence fb Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE recorded higher grain yield and stover yield (63.3 and 83.1 q ha^{-1}, respectively) and it was on par with Atrazine (750 g ha^{-1}) + 2,4 -D Amine (75%) at 25 DAS as PoE (61.9 q ha-

1and 81.7 q ha^{-1}, respectively) and Atrazine at 1.5 kg ha^{-1} pre emergence fb Tembotrione 120 g ha^{-1} at 25 DAS (60.8 and 81.0 q ha^{-1}, respectively). The higher grain yield in these treatments could be attributed to improved yield components such as higher grain weight cob^{-1} and 100 grain weight. The improvement in yield components was inturn due to improved growth attributes such as higher total dry matter production and leaf area index. Thus, the improvement in growth and yield components was as a consequence of lower crop-weed competition, which shifted the balance in favour of crop in utilization of nutrients, moisture, light and space. These results are in conformity with the findings of Saini and Angiras (1998). The lowest grain yield and stover yield was noticed in weedy check as a consequence of greatest removal of nutrients and moisture by weeds and severe crop weed competition resulting in poor source and sink development with poor yield components and higher weed index (Kolage *et al.,* 2004).

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