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# FIELD VALIDATION OF AMMONIUM SULPHATE AS AN ACTIVATOR ADJUVANT ON BROMOXYNIL + MCPA + METRIBUZIN EFFICACY AGAINST MAIZE WEEDS

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**ABSTRACT**

*The use of herbicides is very important for controlling weeds in maize. The efficacy of herbicides can be enhanced with the use of adjuvants. A field experiment was conducted at Agronomic Research Area, University of Agriculture, Faisalabad during autumn 2012 to study the efficacy of bromoxynil + MCPA + metribuzin (Valent-470EW a premixed formulation) with ammonium sulphate as an adjuvant. The experiment comprised of seven treatments namely weedy check, bromoxynil + MCPA + metribuzin @ 1250 mLha$^{-1}$ (commercial product dose), 937.5 mL ha$^{-1}$ @ 1250 mL ha$^{-1}$ + 2% ammonium sulphate, @ 937.5 mLha$^{-1}$ + 2% ammonium sulphate @ 1250 mL ha$^{-1}$ + 4% ammonium sulphate and @ 937.5 mL ha$^{-1}$ + 4% ammonium sulphate. The bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 2% ammonium sulphate gave maximum weed control and minimum dry weight of all weeds. Weed control efficacy was 59-89, 59-100 and 88-100 % for sedges, narrow leaved and broad leaved weeds, respectively. All the yield components, except plant population and number of cobs per plant, were affected significantly and maximum increase in grain yield (66.67%) was achieved by bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 2 % ammonium sulphate.*

**Key words:** Ammonium sulphate, adjuvant, herbicide, maize, weeds.

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## INTRODUCTION

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In Pakistan, maize (*Zea mays* L.) is third important cereal crop after wheat and rice and is used as human staple food, animal feed and raw material for industrial and commercial purposes. It is grown on an area of 0.939 million hectares with national average yield of 3.56 t $ha^{-1}$(Govt. of Pakistan, 2011). The annual production of maize is 3.341 million tons. Although the maize production in Pakistan has been increased from0.38 million tons during 1947-50 to 3.341 million tons in 2011 but it is much less than the developed countries in the world (Govt. of Pakistan, 2011). The main reasons of low yield of maize in Pakistan are imbalanced use of fertilizers, water shortage, improper selection of hybrids, less optimal plant population in the field, poor insects and weeds management. Weeds are one of the most important factors that can reduce maize yield drastically if unchecked. Yield loss due to weeds (37%) is higher than losses caused by pests like mammals, birds, rodents and mites etc. (18%), fungal and bacterial pathogens (16%) and viruses (2%) (Oerke, 2005). Globally maize production is hindered up to 40 %by weeds, as they are the principal pest group for this crop (Oerke and Dehne, 2004). Ashique *et al.* (1997) reported that weeds reduce the yield of maize up to 20-40% by competing with crop for space, light, moisture and nutrients.

Due to labor shortage and frequent monsoon rains during early growth of autumn maize, the cultural method of weeds control is delayed or unable to practice. In such circumstances the chemical method of weed control is effective and economical to increase crop yield (Schaub *et al*., 2006; Noor *et al*., 2011). Generally the post-emergence herbicides enter the plant through the leaf cuticle which is made up of waxes , so it can offer resistance to the herbicide penetration in the plant. The use of adjuvant in combination with herbicide enhances the herbicide retention on leaf surface and penetration through the cuticle.

Nitrogen fertilizers like urea and ammonium sulphate increased the phytotoxic effect of herbicides in maize (Acciaresi *et al*., 2003; Bunting *et al.*, 2004). The combination of fertilizer and herbicide can increase the weed control up to three times in maize (Agladze *et al.*, 2003). An increase in herbicide efficacy and decrease in application dose (up to 17%) has been reported by using combination of herbicide and urea than herbicide used alone (Tahir *et al*., 2011). The use of ammonium sulphate as an adjuvant improved the herbicide activity in hard water, can slightly adjusts the pH, acts as a buffering agent and can improve herbicide uptake and activity (Dogan *et al*., 2002; Turner, 2008).The present study was, therefore, performed to check efficacy of bromoxynil + MCPA + metribuzin in combination with ammonium sulphate as an adjuvant to control weeds in autumn planted maize.

## MATERIALS AND METHODS

The experiment was conducted at Agronomic Research Area, University of Agriculture Faisalabad, Pakistan. The maize hybrid Hycorn-984 was used for the experiment. The experiment comprised of seven treatments i.e. weedy check, bromoxynil + MCPA + metribuzin (Valent-470EW) @ 1250 mL ha$^{-1}$, bromoxynil + MCPA + metribuzin @ 937.5 mLha$^{-1}$, bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 2% ammonium sulphate, bromoxynil + MCPA + metribuzin @ 937.5 mL ha$^{-1}$ + 2% ammonium sulphate, bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 4% ammonium sulphate, bromoxynil + MCPA + metribuzin @ 937.5 mL ha$^{-1}$ + 4% ammonium sulphate. The experiment was laid out in a randomized complete block design with four replications having a net plot size of 7 x 3m. The crop was sown in 75 cm apart rows with a single row hand drill using a seed rate of 25 kg ha$^{-1}$. Plant to plant distance (25 cm) was maintained by thinning out extra plants at early growth stage. Fertilizer was applied @ 250 kg N ha$^{-1}$, 125 kg P ha$^{-1}$ and 125 kg K ha$^{-1}$. Whole P and K in the form of DAP and potassium sulphate, respectively were applied at the time of sowing, while N (urea) in two splits, 1/2 at sowing, 1/2 before flowering. The herbicide was sprayed after emergence of crop and weeds with knapsack sprayer fitted with flat fan nozzle (XR8002, Tee Jet). Spray volume was determined by calibration before spraying.

All other agronomic practices were kept normal and uniform for all the treatments. Weed density and biomass was recorded from an area of 1 m$^2$ from two randomly selected places in each plot. Ten plants were selected at random from each plot for recording data on number of cobs per plant. Three samples of 100- grains were used for recording the 100-grain weight. Grain yield was recorded on per plot basis and was converted to tons ha$^{-1}$.

The data collected were analysed using Fisher's analysis of variance and least significant difference test at 5% probability level was applied to compare the treatment means (Steel *et al*., 1997).

## RESULTS AND DISCUSSION

### Weed density

*Cyperus rotundus* L., *Trianthema portulacastrum* L., *Convolvulus arvensis* L., *Sorghum halepense*, *Cynodon dactylon* L. and *Dactyloctenium aegyptium* L. were the common weeds present in the field but the *T. portulacastrum* and *C. rotundus* were dominant weeds. Individual and total weed density was affected significantly by all the treatments (Table-1 and -2). The bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 2% ammonium sulphate gave maximum weed control. It was followed by bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 4% ammonium sulphate. The minimum density of *T. portulacastrum* and *C. rotundus* was achieved by bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 2% ammonium sulphate and ranged from 0.0 to 0.2 and 0.3 to 24.7 m$^{-2}$, respectively (Table-1, -2). The reduction in the weed density at different times after spray by using ammonium sulphate as an adjuvant can be attributed to increase in retention of herbicide due to adjuvant which increased the toxicity of herbicide. The results are in line with those of Bunting *et al*. (2004) who reported an increase in herbicide efficiency due to use of urea as an adjuvant.

The maximum reduction in the density of *C. rotundus,* and *S. halepense* was recorded by bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 2% ammonium sulphate and ranged from 2.75 to 6.5 m$^{-2}$ (Table-1). This might have been due to increased retention of herbicide on the leaves of weeds (Zadorozhny, 2004). These results are in line with those of Bunting *et al*. (2004). They reported increased herbicide efficiency due to use of adjuvant.

*Trianthema portulacastrum* and *C. rotundus* almost completed their life cycle and only a few plants were present in the field at the time of harvest and another weed *Physalis alkekengi* also appeared in the field six weeks after spray and was present at the time of harvest (Table-1, -2). The bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 2% ammonium sulphate gave the maximum control of *C. dactylon and D. aegyptium* which ranged from 59 to 64 and 88 to 100%, respectively (Table-1). The maximum density in weedy check can be attributed to favorable conditions for weed germination and growth in the absence of weed control practices. Khan and Haq (2004) have also reported maximum weed density in weedy check compared to herbicide treatments.

**Dry weight of weeds at harvest**

The dry weight of all the weeds was affected significantly (Fig. 1) by herbicide applicaiton. The minimum dry weight was obtained with bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 2% ammonium sulphate. It was followed by the bromoxynil + MCPA + metribuzin @ 1250 mL ha$^{-1}$ + 4% ammonium sulphate which was statistically at par with bromoxynil + MCPA + metribuzin @ 1250 mLha$^{-1}$. Maximum weed dry weight in weedy check can be attributed to maximum weed density. Further, unchecked growth of the weed plants in the absence of any weed control practice also resulted in higher weed dry weight. The results are in accordance with those of Khan and Haq (2004) who also reported maximum dry weight in weedy check compared to herbicide treatments. The decrease in the dry weight of weeds due to the addition of adjuvant can be attributed to increased phytotoxic effect of herbicide and decreased density of weeds. The results are supported by the findings of the Amanullah

(2001) who reported decrease in weed biomass due to use of urea as an adjuvant with post-emergence herbicide.

**Yield and yield components of maize.**

The plant population and the number of cobs per plant was not affected significantly by different weed control treatments and ranged from 6.25 to 6.75$m^{-2}$ and 1.03 to 1.06, respectively (Table-3). The non-significant differences among herbicides for number of cobs per plant have also been reported by Khan *et al*. (2002). The differences among the treatments for number of grains per cob were significant. The maximum number of grains per cob and 100-grain weight was recorded with bromoxynil + MCPA + metribuzin @ 1250 mL $ha^{-1}$ + 2% ammonium sulphate and was statistically at par with bromoxynil + MCPA + metribuzin @ 1250 mL $ha^{-1}$ + 4% ammonium sulphate (Table-3). The higher number of grains per cob and 100-grain weight in these treatments can be attributed to lower weed density and competition for the available resources. The results are supported by the findings of Amanullah (2001) and Khan *et al*. (2002) who reported minimum number of grains per cob in weedy check. The minimum 100-grain weight was observed in weedy check which can be attributed to the greater weed-crop competition exerted by the maximum number of weeds which resulted in reduced plant growth (Table 3). The results are in line with those of Khan and Haq (2004) who reported minimum grain weight in weedy check treatment. Grain yield of maize was also affected significantly by all treatments and minimum grain yield was recorded in weedy check. The bromoxynil + MCPA + metribuzin @ 1250 mL $ha^{-1}$ + 2 % ammonium sulphate gave maximum grain yield and resulted in 66.67% increase in grain yield over weedy check and it was statistically at par with bromoxynil + MCPA + metribuzin @ 1250 mL $ha^{-1}$ + 4 % ammonium sulphate which gave higher grain yield to the tune of 66.24% over weedy check (Table-3). The higher grain yield in these treatments was in accordance with the yield attributing components, which showed higher values. The minimum grain yield in weedy check can be attributed to lower number of grains per cob and lower 100- grain weigh. The role of yield attributing factors and enhanced yield on account of weed control with herbicides and adjuvants has also been reported earlier by Khan *et al*. (2002), Amanullah (2001) and Bunting *et al*. (2004).

## CONCLUSION

Based on the present findings it can be concluded that the maximum weed control and higher grain yield of maize was obtained by bromoxynil + MCPA + metribuzin @ 1250 mL $ha^{-1}$ with 2% or 4% ammonium sulphate.

**Table-1.** Effect of bromoxynil + MCPA + metribuzin with ammonium sulphate as an adjuvant on sedges and narrow leaf weeds of maize

| Herbicide Bromoxynil + MCPA + metribuzin (ml ha$^{-1}$) | Adjuvant $(NH_4)_2SO_4$ (%) | *C. rotundus* | | | *S. halepense* | | | *C.dactylon* | | | *D. aegyptium* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 3WAS | 6WAS | At crop harvest | 3WAS | 6WAS | At crop harvest | 3WAS | 6WAS | At crop harvest | 3WAS | 6WAS | At crop harvest |
| Weedy check | - | 60.75 a | 51.25 a | 2.71 a | 10.0 a | 25.0 a | 22.5 a | 4.25 a | 9.75 a | 6.25 a | - | 4.5 a | 10.5 a |
| 1250 | - | 33.75 c (44) | 28.0 d (45) | 0.0 b (100) | 5.25 bc (47) | 10.7 cd (58) | 10.0 d (58.0) | 1.5 ab (65) | 5.0 bc (49) | 2.75 cd (56) | - | 1.5 bc (67%) | 5.75 bc (45%) |
| 937.5 | - | 41.0 b (32) | 35.0 b (32) | 0.52 b (81) | 9.25 a (7) | 16.25 b (35) | 15.25 b (35) | 1.0 b (76) | 7.75 ab (20) | 4.25 bc (32) | - | 2.25 b (50%) | 8.00 b (24%) |
| 1250 | 2 | 24.75 e (59) | 19.50 f (62) | 0.30 b (89) | 2.75 d (72) | 6.50 e (74) | 5.75 f (74) | 1.75 ab (59) | 4.0 c (59) | 2.25 de (64) | - | 0.50 bc (89%) | 0.0 d (0.0%) |
| 937.5 | 2 | 34.75 c (43) | 29.75 c (42) | 0.52 b (81) | 7.0 b (30) | 13.5 bc (46) | 12.50 c (46) | 2.75 ab (35) | 6.75 abc (31) | 4.0 bcd (36) | - | 1.75 bc (61%) | 5.50 c (48%) |
| 1250 | 4 | 28.75 d (53) | 23.25 e (55) | 0.0 b (0.0) | 4.75 c (52) | 8.75 de (65) | 7.75 e (65) | 1.50 ab (65) | 6.0 bc (38) | 0.75 e (88) | - | 0.0 c (0.0%) | 4.50 c (57%) |
| 937.5 | 4 | 35.25 c (42) | 29.75 c (42) | 0.0 b (100) | 6.25 bc (37) | 11.0 cd (56) | 11.50 cd (56) | 3.00 ab (29) | 7.0 abc (28) | 4.75 ab (24) | - | 1.25 bc (72%) | 4.0 c (62%) |
| LSD | | 1.82 | 1.72 | 1.24 | 1.77 | 3.95 | 1.53 | 2.82 | 3.26 | 1.84 | | 1.91 | 2.5 |

Means not sharing the same letters differ significantly at 5% level of probability.
Fig. in parentheses shows % decrease over weedy check
WAS = weeks after spray

**Table-2.** Effect of bromoxynil + MCPA + metribuzin with ammonium sulphate as an adjuvant on broad leaf weeds of maize

| Herbicide Bromoxynil + MCPA + metribuzin (ml $ha^{-1}$) | Adjuvant $(NH_4)_2SO_4$ (%) | *T. portulacastrum* | | | *C. arvensis* | | | *P. alkekengi* | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 3WAS | 6WAS | At crop harvest | 3WAS | 6WAS | At crop harvest | 3WAS | 6WAS | At crop harvest |
| Weedy check | - | 50.2 a | 26.5 a | 11.5 a | 1.0 | 2.5 a | 3.0 a | - | - | 2.2 a |
| 1250 | - | 2.0 d (96) | 1.2 d (95) | 0.5 bc (96) | 0.2 | 1.7 ab (30) | 1.7 bc (42) | - | - | 0.7 cd (67%) |
| 937.5 | - | 8.5 b (83) | 5.0 b (81) | 1.2 b (89) | 0.7 | 1.7 ab (30) | 2.7 ab (8) | - | - | 1.7 ab (22%) |
| 1250 | 2 | 0.2 e (99) | 0.2 d (99) | 0.0 c (100) | 0.0 | 0.2 c (90) | 0.5 d (83) | - | - | 0.2 d (88%) |
| 937.5 | 2 | 4.7 c (90) | 2.7 c (90) | 0.7 bc (93) | 0.5 | 2.0 ab (20) | 1.5 cd (50) | - | - | 1.7 ab (22%) |
| 1250 | 4 | 1.2 d (97) | 0.5 d (98) | 0.2 bc (98) | 0.5 | 1.0 bc (60) | 1.2 cd (58) | - | - | 1.0 c (55%) |
| 937.5 | 4 | 4.7 c (90) | 3.0 c (89) | 0.7 bc (93) | 0.5 | 2.2 ab (10) | 2.0 abc (33) | - | - | 1.2 bc (44%) |
| LSD | | 0.92 | 1.22 | 1.05 | NS | 1.28 | 1.22 | - | - | 0.694 |

Means not sharing the same letters differ significantly at 5% level of probability.
Fig. in parentheses shows % decrease over weedy check
WAS = weeks after spray

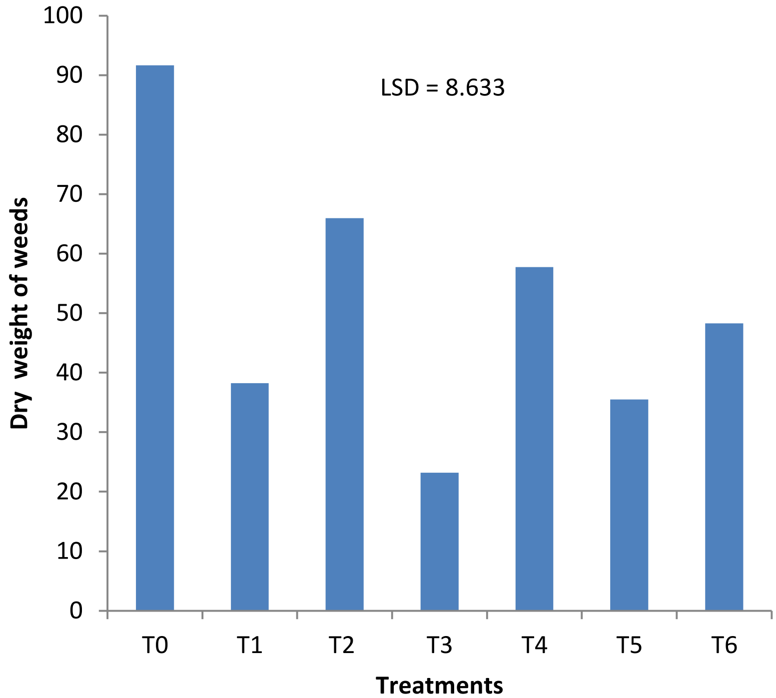


**Figure 1.** Effect ofbromoxynil + MCPA + metribuzin and ammonium sulphate as an adjuvant on dry weight (gm$^{-2}$) of weeds in maize at harvest

$T_0$ (weedy check),
$T_1$ (bromoxynil+MCPA+metribuzin@1250),
$T_2$ (bromoxynil+MCPA+metribuzin @937.5 ml ha$^{-1}$),
$T_3$ (bromoxynil+MCPA+metribuzin @1250 ml ha$^{-1}$ + 2% ammonium sulphate),
$T_4$ (bromoxynil+MCPA+metribuzin @937.5 ml ha$^{-1}$ + 2% ammonium sulphate),
$T_5$ (bromoxynil+MCPA+metribuzin @1250 ml ha$^{-1}$ + 4% ammonium sulphate) and
$T_6$ (bromoxynil+MCPA+metribuzin @937.5 ml ha$^{-1}$ + 4% ammonium sulphate)

**Table-3.** Effect of bromoxynil + MCPA + metribuzin with ammonium sulphate as an adjuvant on yield and yield components of maize

| Herbicide Bromoxynil + MCPA + metribuzin (ml $ha^{-1}$) | Adjuvant $(NH_4)_2SO_4$ (%) | Plant population ($m^{-2}$) | Number of cobs per plant | Number of grains per cob | 100-grain weight (g) | Grain yield (t $ha^{-1}$) |
|---|---|---|---|---|---|---|
| Weedy check | - | 6.25 | 1.03 | 550.50 d | 22.14 e | 4.77 e |
| 1250 | - | 6.50 | 1.04 | 584.50 b | 26.52 b | 7.47 b (56.6) |
| 937.5 | - | 6.25 | 1.04 | 565.25 c | 24.98 d | 6.81 d (42.76) |
| 1250 | 2 | 6.75 | 1.06 | 607.50 a | 28.40 a | 7.95 a (66.67) |
| 937.5 | 2 | 6.50 | 1.04 | 581.75 b | 26.12 bc | 7.41 bc (55.34) |
| 1250 | 4 | 6.75 | 1.05 | 604.75 a | 28.23 a | 7.93 a (66.24) |
| 937.5 | 4 | 6.50 | 1.03 | 570.0 c | 25.84 c | 7.27 c (52.41) |
| LSD | - | NS | NS | 11.618 | 0.44 | 0.15 |

Means not sharing the same letters differ significantly at 5% level of probability.
Fig. in parentheses shows % increase over weedy check

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