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The Influence of pre-and Post-Emergence Herbicides on the Growth and Grain Yield of Wheat (Triticum Aestivum L.) at Kadawa , Nigeria

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Abstract
The study evaluated 15 pre-and post-emergence herbicides (alone and in combination) assessed alongside a hoe weeded control (weeded at 3 and 6 weeks after sowing (WAS)) and a weedy check during 2002/03 and 2003/04 dry seasons at Kadawa in Sudan Savannah of Nigeria. The trial was laid out in a randomized complete block design and replicated four times. The result showed that Oxadiazon at 1.0kga.i/ha, propanil plus bentazon at 2.0 + 1.0kg a.i/ha and metolachlor plus prometryne at 1.25 + 1.25kg a.i/ha gave the best result and could be adopted for wheat production in Nigeria. Propanil plus 2,4-D at 2.88 + 1,60kg a.i/ha, 2,4-D at 1.5 and 2.0kg a.i/ha, mixtures of metolachlor plus terbutryne at 1.0 + 1.0 and prometryne at 1.0 + 1.0kg a.i/ha selectively suppressed weeds compared to the weedy check. Sole rates of atrazine at 1.5 and 2.0kg a.i/ha and its mixtures with metolachlor at 1.0 + 0.5, 1.33 + 0.66 and 1.66 + 0.83 kg a.i/ha gave effective weed control up to 6WAS but significantly reduced wheat grain yield. Atrazine treatments particularly at 2.0kg a.i/ha proved phytotoxic to wheat with noticeable symptoms of growth and grain yield depression comparable to the weedy check. Uncontrolled weed growth throughout the crop's life cycle resulted in 43.72 percent mean yield loss compared to the best treatment (metolachlor plus prometryne at 1.25 + 1.25kg a.i/ha) in the trial.
Keywords: Herbicides, mixtures, weed, growth characters and yield.

Introduction.

Wheat (*Triticum aestivum* L.) is an important food and industrial crop grown in Nigeria under irrigation in areas within latitude 10 and 14^{o}N during the period between November and March, which is characterized by cool temperatures (Mustapha, 1998). In 2002, total world production of wheat was estimated at 572.7 million metric tones on 213.5 million hectares of land with average yield of 2.7 t/ha. In Africa, average yield of 2.0t/ha was harvested from 8.1 millionhectares of land while in Nigeria, total production indicated 0.06 million tones from 0.06 million hectares of land (F.A.O, 2003).

Inspite of the importance of wheat in Nigeria, average yield of the crop on farmer farm very low, (1.0t/ha) compared to the world average of 2.7t/ha. (F.A.O, 2003). This is due to some constraints such as climatic factors (temperature, radiation, photoperiodism), soil factors (moisture, soil texture and fertility status), biotic factors (weeds, pest, diseases and crop varieties) and agronomic factors (land preparation, time of planting, seed rate and fertilizer application) (Saleh, 1977; Khalifa, 1970). Of all these constraints, the biotic factors are the most important as uncontrolled weed growth throughout the crop life cycle has been reported to cause 30-70 percent losses in wheat grain yield (Kataria, 1981; Tu, 1991). Weed infestation in irrigated lands has become more complex due to multiple cropping in both the dry and wet seasons resulting to the proliferation of numerous weed species that can cause substantial yield reduction if left unchecked (Dadari, 1988).

Common method of weed control in irrigated wheat in northern Nigeria is by manual hoe-weeding and hand pulling. These methods are labour intensive, tedious, time consuming, expensive and could result in root pruning and reduction in stand count (Dadari, 1988). As a result of these limitations, weed control is not usually accurate and adequate, resulting in grain yield losses. Weed control by herbicides has been found to be very efficient and devoid of the above limitations, and thus results in reduced weed competition, crop losses, labour/cost of production and increase profitability in field crop production (Lagoke and Shebayan, 1988). Herbicides recommend for season-long weed control in wheat in the northern Guinea and Sudan savanna such as bentazon at 1.2kg a.i/ha and chlortoluron plus chlorbromuron at 1.0 + 1.5kg a.i/ha are currently unavailable and even when found, are expensive compared to the other herbicides with the same weed control spectrum used for weed control in rice and maize in the same wheat growing environment. Herbicides used for these crops are not only readily available, but are also cheaper than those for wheat. In rice, oxadiazon, 2,4-D, propanil and bentazon have been recommended alone or in combination with others, while for maize, the recommended herbicides are mixtures of metolachlor plus atrazine (primextra), metolachlor plus terbutryne (Igran combi) and metolachlor

plus prometryne (Codal) (Anon., 1994) However, the herbicides used in rice and maize have not been evaluated on wheat. It is in the light of this that this trial was proposed to:

- Evaluate the tolerance of irrigated wheat to pre-and post-emergence herbicides that are recommended for rice and maize on irrigated wheat at Kadawa.
- Assess the weed control efficacy of these herbicides on irrigated wheat.

Materials and methods

Field experiments were conducted under Irrigation Research Station of the institute for Agricultural Research, Kadawa ($11^{o}39'$N $08^{o}27'$E and 500m above sea level) during the 2002/2003 and 2003/2004 dry seasons. Kadawa is located in the Sudan savannah ecological zone of Nigeria. Wheat variety CV siste ceros was broadcasted on irrigation basins ($12m^2$ each) which constituted experimental plot at the rate of 100kg/ha and gently raked into the soil on the 6^{th} and 14^{th} December, in 2002 and 2003, respectively.

The treatments consisted of 15 pre-and post-emergence herbicides (alone and in combinations) assessed alongside a hand weeded control (weeded at 3 and weeks after sowing" WAS") and a weedy check. Pre-emergence treatments comprised oxadiazon at 1.0kg a.i/ha, metolachlor plus Atrazine at 1.0 + 0.5, 1.33 + 0.66 and 1.66 + 0.83kg a.i/ha, metolachlor plus terbutryne at 0.75 + 0.75 and 1.0 + 1.0kg a.i/ha, atrazine at 1.5 and 2.0kg a.i/ha and metolachlor plus prometryne at 0.75 + 0.75, 1.0 + 1.0 and 1.25 + 1.25kg a.i/ha; and post-emergence treatments were propanil plus 2,4-D at 2.88 + 1.6kg a.i/ha, propanil plus bentazon at 2.0 + 1.0kg a.i/ha and 2,4-D at 1.5 and 2.0 kg a.i/ha. The experiment was laid in a randomized complete block design and replicated four times. The gross plot size was 4.0m x 3.0m ($12m^2$) and the net plot size was 3.0m x 3.0m ($9.0m^2$). Irrigation was done immediately after seeding and subsequently continued at weekly intervals until 3 weeks to harvest, when the crop was allowed to completely dry so as to ease harvesting and threshing. All pre-emergence herbicides treatments were applied a day after sowing and post emergence herbicides applied at 2 weeks after sowing (WAS) when the weeds were tender to effective control. Both applications were done using a CP3 knapsack sprayer fitted with a green deflector nozzle. The sprayer was set at 2.1-kg/cm^2 pressure to deliver 220 I/ha of the spray solution. The hand weeded control was weeded by hand pulling at 3 and 6WAS.

Fertilizers were applied at the rate of 120kg N/ha, 26.2kg P/ha and 49.8kg K/ha. Half of the nitrogen and all of phosphorus and postassium were applied at 3 WAS using NPK (15:15:15) Compound fertilizer. The remaining half of nitrogen was applied at 6WAS after sowing as urea (46%N).

Data collected were weed dry weight, crop establishment score, crop vigour score, plant height, number of tillers and grain yield.

The data collected were subjected to statistical analysis of variance (ANOVA) using the 'F' test as described by Snedecor and Cochran (1967). Where treatment means were significantly different, they were compared using the Duncan's Multiple Range Tests (DMRT) at 5% level of probability (Duncan, 1955).

Results and discussion

The weedy check had significantly higher weed cover score and weed dry weight than the hoe weeded control and all the herbicide treatments except atrazine and its mixtures with metolachlor at 1.66 + 0.83 and 1.33 + 0.66kg a.i/ha and 2,4-D at 1.5 and 2.0kg a.i/ha in 2002/03. This result agrees with the findings of Adeosun *et. al.* (1994) and Atangs (1997) who, working on rice, reported that the weedy check had produced higher weed cover score and weed dry matter than all the herbicides evaluated in the trials. Uncontrolled weed growth throughout the crop's life cycle resulted mean weed dry weight of 1645.6kg/ha at harvest compared to 2525kg/ha as report by Dadari and Mani (2005) at the same site with the same crop in 2001/02 dry season. Among the herbicides evaluated, Oxadiazon at 1.0kg a.i/ha and metolachlor plus prometryne at 1.25 + 1.25kg a.i/ha combined effective weed control (low weed dry weight) with good crop performance as expressed in parameters like crop establishment, crop vigour, plant height and yield due to high level of tolerance of the crop to the herbicide treatments and reduced competition as a result of effective weed control by the herbicides. Audus (1976) had earlier reported that suitability of herbicides for use in any crop depends on its effective weed control and tolerance. This observation agrees with earlier report by Dadari and Mani, (2005) who found that oxadiazon plus propanil at 1.0 + 2.0kg a.i/ha gave season long control of weeds in wheat. Ishaya (2004) also earliar reported that application of oxadiazon at 1.0 and 1.25kg a.i/ha to rice and maize mixture reduced weed infestation comparable to hoe weeding at 3 and 6WAS. The observed effectiveness of these herbicides on weeds could also be attributed to the broad-spectrum activity of the herbicides on broadleaved weeds, sedges and grasses, which were found on the experimental sites. Akobundu (1987) reported that oxadiazon causes foliar burn on contact with weeds, while metolachlor and prometryne inhibit root and shoot growth through inhibiting photosynthesis, protein and lipid synthesis. However, propanil plus 2,4-D at 2.88 + 1.6kg a.i/ha, metolachlor plus prometryne at 1.0 + 1.0kg a.i/ha, propanil plus bentazon at 2.0 + 1.0kg a.i/ha, metolachlor plus terbutryne at 1.0 + 1.0kg a.i/ha, metolachlor plus atrazine at 1.66 + 0.83 and 1.33 + 0.66kg a.i/ha were comparable to the above treatments in weed control,

indicating their potentials in controlling weeds in wheat.

Among the herbicides evaluated, Oxadiazon at 1.0kg a.i/ha, metolachlor plus prometryne at 1.25 + 1.25kg a.i/ha combined effective weed control (low weed cover score and low weed dry weight) with good crop performance as expressed in parameters like crop establishment, crop vigour, number of tillers, total dry matter, spike length, grain weight per spike, 1000-grainweight and grain yield due to high level of tolerance of the crop to the herbicide treatments and reduced competition as a result of effective weed control by the herbicides. Audus (1976) had earlier reported that suitability of herbicides for use in any crop depends on its effective weed control and tolerance. This observation agrees with earlier report by Dadari and Mani, (2005) who found that oxadiazon plus propanil at 1.0 + 2.0kg a.i/ha gave season long control of weeds in wheat. Ishaya (2004) also earlier reported that application of oxadiazon at 1.0 and 1.25kg a.i/ha to rice and maize mixture reduced weed infestation comparable to hoe weeding at 3 and 6WAS. The observed effectiveness of these herbicides on weeds could also be attributed to the broad-spectrum activity of the herbicides on broadleaved weeds, sedges and grasses, which were found on the experimental sites. Akobundu (1987) reported that oxadiazon causes foliar burn on contact with weeds, while metolachlor and prometryne inhibit root and shoot growth through inhibiting photosynthesis, protein and lipid synthesis. However, propanil plus 2,4-D at 2.88 + 1.6kg a.i/ha, metolachlor plus prometryne at 1.0 +1.0kg a.i/ha, propanil plus bentazon at 2.0 + 1.0kg a.i/ha, metolachlor plus terbutryne at 1.0 + 1.0kg a.i/ha, metolachlor plus atrazine at 1.66 + 0.83 and 1.33 + 0.66kg a.i/ha were comparable to the above treatments in weed control, indicating their potentials in controlling weeds in wheat.

The establishment and growth of wheat as reflected in the crop establishment score, crop vigour score and plant height were all affected by the weed control treatments. The application of oxadiazon at 1.0kg a.i/ha, propanil plus bentazon at 2.0 + 1.0kg a.i/ha and metolachlor plus prometryne at 1.25 + 1.25kg a.i/ha gave crop vigour score, crop establishment and plant height comparable to the hoe weeded control. This is an indication that the herbicides at the given rates were selective on the crop and were applied at the right stage of the crop's growth. These observations agreed with the findings of Dadari and Mani (2005), who reported that bentazon plus propanil at 1.0kg a.i/ha oxadiazon plus propanil at 1-3kg a.i/ha enhanced growth parameters such as crop establishment score, crop vigour score and plant height. The observed significant reduction in crop establishment and crop vigour with sole atrazine at 1.0 and 2.0kg a.i/ha and its mixtures with metolachlor at 1.0 +0.5, 1.33 + 0.66 and 1.66 + 0.83kg a.i/ha is as a result of poor crop tolerance to atrazine. Akobundu, (1987) reported that S-triazines are photosynthesis inhibitors.

All the weed control treatments, with the execption of atrazine and its mixtures with metolachlor at 1.33 + 0.66 and 1.66 + 0.83kg a.i/ha, increased wheat yield over that of the weedy check. It is apparent that the yield obtained is a reflection of combination of weed control and selectivity of the herbicides in the crop. Fryer and Makepeace (1977) reported that yield obtained from any treatment is dependent on level of weed control and crop tolerance. This agrees with Prusty *et al.* (1988) who reported that herbicides boost crop yield due to effective control of weeds. Kulmi (1991) reported that yields are increased with effective weed control. It is also important to note that grain yields from hoe weeded control and the best herbicide treatment were statistically at par indicating that weed growth and interference in wheat is severe between 3 and 6 WAS, a period that coincides with the critical part of the vegetative phase of the crop. This agrees with the findings of shebayan (1998) who reported that it is advantageous to control weeds at the critical stage of the crop growth since allowing weeds infestation at this tender stage could result in growth depression and consequent yield reduction. Season-long weed infestation from the weedy check resulted in 43.72 percent reduction in wheat grain yield compared to 45.34 percent mean grain yield reduction from untreated plots (Dadari and Mani, 2005). The highest mean grain yield of 2046.8kg/ha (metolachlor plus prometryne at 1.25 + 1.25kg a.i/ha) is 24 percent higher than earlier obtained at the site in 200/2001 with oxadiazon plus Propanil at 1.0 + 1.0kg a.i/ha applied post-emergence (Dadari and Mani, 2005) The better yield in this work could be attributed to the good combinations of herbicides evaluated and their efficacy. Low yield from the weedy check was due to high weed infestation. This agrees with Akobundu and Fagade (1978) who reported that weed infestation depresses grain yield. Application of atrazine at 1.5 and 2.0kg a.i/ha controlled weeds only up to 6WAS but adversely affected the crop resulting to the yield being significantly lower than the weedy check.

Table 1: Effect of pre-emergenceherbicides on weed cover scores, total dry matter and crop establishment score of irrigated wheat in Kadawa 2002/03 and 2003/04 dry seasons

		Weed cover score at 9WAS[1]		Total weed dry matter (g/m^2)		Crop establishment score at harvest	
Treatment	Rate (kg a.i./ha)	2002/03	2003/04	2002/03	2003/04	2002/03	2003/04
Oxidiazon	1.00	2.25^{cd2}	1.50^{c}	0.68^{ab}	0.64^{a-c}	8.60^{ab}	8.30^{ab}
Propanil + 2,4-D	2.88+1.60	2.25^{cd}	2.13^{c}	0.63^{bc}	0.61^{bc}	7.80^{a-c}	8.50^{ab}
Propanil + 2,4-D	2.00+1.00	2.00^{d}	4.20^{a-c}	0.71^{ab}	0.58^{b-d}	7.50^{a-c}	8.30^{ab}
2,4-D	1.50	2.00^{d}	3.75^{a-c}	0.58^{bc}	0.59^{bc}	7.30^{a-c}	8.40^{ab}
2,4-D	2.00	2.25^{cd}	3.50^{a-c}	0.68^{ab}	0.68^{bc}	7.60^{a-c}	8.00^{ab}
Metolachlor+ atrazine	1.00+0.50	2.75^{b-d}	1.50^{c}	0.66^{ab}	0.51^{c-e}	6.90^{a-d}	7.10^{b}
Metolachlor+ atrazine	1.33+1.66	4.00^{a-c}	1.63^{c}	0.65^{a-c}	0.19^{f}	6.90^{a-d}	1.80^{c}
Metolachlor+ atrazine	1..66+0.83	3.00^{b-d}	4.13^{a-c}	0.63^{bc}	0.13^{f}	6.90^{a-d}	0.80^{cd}
Metolachlor+ terbutryne	0.75+0.75	2.75^{b-d}	1.63^{c}	0.54^{bc}	0.60^{bc}	7.90^{bc}	8.80^{a}
Metolachlor+terbutryne	1.00+1.00	4.25^{ab}	3.38^{a-c}	0.63^{bc}	0.66^{a-c}	8.50^{a-c}	8.20^{ab}
Atrazine	1.50	4.25^{ab}	3.75^{a-c}	0.49^{bc}	0.14^{f}	6.40^{b-d}	1.80^{c}
Atrazine	2.00	2.50^{b-d}	3.25^{a-c}	0.53^{bc}	0.08^{f}	4.90^{d}	4.75^{d}
Metolachlor+prometryne	0.75+0.75	2.25^{cd}	3.13^{bc}	0.69ab	0.53^{c-e}	5.80^{cd}	8.10^{ab}
Metolachlor+prometryne	1.00+1.00	2.25^{cd}	1.38^{c}	0.68^{ab}	0.64^{a-c}	8.10^{a-c}	8.30^{ab}
Metolachlor+prometryne	1.25+1.25	2.25^{cd}	3.63^{a-c}	0.85^{a}	0.66^{a-c}	9.10^{a}	8.90^{a}
Hoe weeded control (3&6 WAS)	-	5.00^{a}	6.00^{a}	0.66^{ab}	0.75^{ab}	7.50^{a-c}	8.50^{b}
Weedy check	-			0.49^{c}	0.39^{c}	4.50^{d}	2.10^{d}
S.E.(±)		0.400	0.255	0.031	0.027	3.192	1.936

[1]WAS = Weeks after sowing
[2]Means in the same column followed by unlike letter are significantly at 5% probability using Duncan's Multiple Range Test (DMRT).

Table 2: Effect of pre- and post-emergence herbicides on plant height of irrigated wheat during 2002/2003 and 2003/2004 dry seasons in Kadawa

			Plant Height(cm)					
Treatment	Rate (kg a.i./ha)	Time of Application	3WAS[1]		6WAS		9WAS	
			2002/03	2003/04	2002/03	2003/04	2002/03	2003/04
Oxidiazon	1.0	pre-emergence	5.75bc[2]	7.13ab[2]	29.50abcde	33.70ab	71.43ab	90.58ab
Propanil + 2,4-D	2.88+1.6	post-emergence	6.73abc	6.63ab	29.43abcde	32.72ab	77.15ab	81.60bc
Propanil + 2,4-D	2.0+1.0	,, ,,	6.40abc	7.50a	30.28abcde	3193ab	77.00ab	91.50ab
2,4-D	1.5	,, ,,	6.50abc	7.18ab	31.58abed	33.68ab	69.50ab	92.25ab
2,4-D	2.0	,, ,,	6.40abc	7.18ab	33.75a	32.80ab	72.15ab	80.68bc
Metolachlor+ atrazine	1.0+0.5	pre-emergence	6.58abc	6.40abc	31.75abcde	29.15b	82.35a	81.75bc
Metolachlor+ atrazine	1.33+0.66	,, ,,	5.98abc	6.38abc	31.33abcd	27.18bc	74.93ab	75.50cd
Metolachlor+ atrazine	1..66+0.83	,, ,,	6.68abc	4.98cd	29.15abcde	20.78d	76.58ab	45.33e
Metolachlor+ terbutryne	0.75+0.75	,, ,,	6.43abc	7.20ab	29.45abcde	30.18b	72.43ab	89.60abc
Metolachlor+terbutryne	1.0+1.0	,, ,,	6.23abc	7.25ab	28.18abcde	29.03d	75.58ab	90.43ab
Atrazine	1.5	,, ,,	7.00a	5.68bc	26.58bcde	22.93cd	74.48ab	64.23d
Atrazine	2.0	,, ,,	5.68c	4.05d	24.15e	17.33d	66.10b	34.85e
Metolachlor+prometryne	0.75+0.75	,, ,,	6.30abc	6.78ab	32.15abc	32.55ab	73.85ab	95.10abc
Metolachlor+prometryne	1.0+1.0	,, ,,	6.55bc	7.00ab	26.58bcde	30.65ab	70.98ab	85.68abc
Metolachlor+prometryne	1.25+1.25	,, ,,	6.73abc	6.88ab	32.53ab	32.85ab	77.15ab	95.60ab
Handed weeded control	3 and 6WAS	,, ,,	6.30abc	7.75a	26.00cde	36.35a	71.48ab	98.03a
Weedy check			6.80ab	7.20ab	25.50de	33.10ab	67.93b	47.50e
S.E. ±	-		0.07	0.12	0.44	0.47	0.92	1.04

1 Weeks after sowing
2 Means in the same column of treatments followed by unlike letter are significantly different at 5% level of probability using Duncan Multiple Range Test (DMRT)

Table 3: Effect of pre- and post-emergence herbicides on crop establishment score of irrigated wheat during 2002/2003 and 2003/2004 dry seasons in Kadawa

Treatment	Rate (kg a.i./ha)	Time of Application	Crop establishment score[1] 3WAS[2]		Number of tillers/plant at Harvest Harvest			
			2002/03	2003/04	2002/03	2003/04	2002/03	2003/04
Oxidiazon	1.0	pre-emergence	7.1abcd[3]	7.5ab	8.6ab1	8.3ab	5.15ab[1]	6.35ab
Propanil + 2,4-D	2.88+1.6	post-emergence	7.5abc	6.0bc	7.8abc	8.5ab	4.23ab	4.58bc
Propanil + 2,4-D	2.0+1.0	,, ,,	7.8ab	8.0a	7.5abc	8.3ab	5.38ab	4.70bc
2,4-D	1.5	,, ,,	6.8abcd	8.9a	7.3abc	8.0ab	4.97ab	4.65bc
2,4-D	2.0	,, ,,	7.5abc	8.3a	7.6abc	8.0ab	5.15ab	4.63bc
Metolachlor+ atrazine	1.0+0.5	pre-emergence	7.1abcd	4.1de	6.9abcd	7.1b	4.43ab	5.03bc
Metolachlor+ atrazine	1.33+0.66	,, ,,	5.9cde	2.8ef	6.9abcd	1.8c	4.75ab	4.83bc
Metolachlor+ atrazine	1..66+0.83	,, ,,	5.5de	2.1f	6.9abcd	0.8cd	4.93ab	4.93bc
Metolachlor+ terbutryne	0.75+0.75	,, ,,	7.4abc	6.0bc	7.9abc	8.8a	5.00ab	4.98bc
Metolachlor+terbutryne	1.0+1.0	,, ,,	6.5abcde	5.5cd	8.5ab	8.2ab	5.15ab	5.08bc
Atrazine	1.5	,, ,,	4.9e	4.0de	6.4bcd	1.8c	5.00ab	4.48bc
Atrazine	2.0	,, ,,	3.0f	1.8f	4.9d	4.75d	5.18ab	3.00d
Metolachlor+prometryne	0.75+0.75	,, ,,	7.8ab	7.6ab	5.8cd	8.1ab	4.68ab	4.80bc
Metolachlor+prometryne	1.0+1.0	,, ,,	6.1bcde	5.6cd	8.1abc	8.3ab	4.98ab	6.50ab
Metolachlor+prometryne	1.25+1.25	,, ,,	7.4abc	6.1bc	9.1a	8.9a	6.33a	6.75a
Handed weeded control	3 and 6WAS	,, ,,	6.5abcde	9.1a	7.5abc	8.5ab	4.75ab	4.68bc
Weedy check			8.3a	9.4a	4.5d	2.1d	3.75b	4.10cd
S.E. ±	-		0.12	1.13	0.09	0.16	0.146	0.091
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1. Base on scale 1-10 where 1 = zero crop establishment and 10 = full establishment.
2. Weeks After Sowing
3. Means in same column of treatment followed by unlike letter are significantly different at 5% level of probability using Duncan Multiple range test (DMRT)

Table 4: Effect of pre- and post-emergence herbicides on Crop vigour score of irrigated wheat during 2002/2003 and 2003/2004 dry seasons at Kadawa

Treatment	Rate (kg a.i./ha)	Time of Application	Crop vigour score[1] 3WAS[1]		6WAS		9WAS	
			2002/03	2003/04	2002/03	2003/04	2002/03	2003/04
Oxidiazon	1.0	pre-emergence	7.00abc[3]	7.0cde[3]	8.00a	8.25ab	9.13a	8.25ab
Propanil plus 2,4-D	2.88+1.6	post-emergence	7.75abc	6.25def	7.50ab	7.75ab	8.50ab	7.25b
Propanil plus bentazon	2.0+1.0	,, ,,	7.50abc	8.25abc	8.00a	7.75abc	8.75a	8.50ab
2,4-D	1.5	,, ,,	6.75abc	9.25a	7.00abc	8.50ab	7.75ab	8.75ab
2,4-D	2.0	,, ,,	7.75ab	8.75ab	5.50abc	8.50ab	7.75ab	8.00ab
Metolachlor plus atrazine	1.0+0.5	pre-emergence	7.25abc	5.00fgh	7.75a	4.75d	8.38ab	5.50c
Metolachlor plus atrazine	1.33+0.66	,, ,,	6.00cd	3.75h	5.75abc	2.75e	7.50ab	3.25d
Metolachlor plus atrazine	1..66+0.83	,, ,,	6.50bcd	2.25i	5.00bc	1.25e	8.50ab	1.50e
Metolachlor plus terbutryne	0.75+0.75	,, ,,	7.75ab	6.25def	7.50ab	7.25abc	8.25ab	7.75ab
Metolachlor plus terbutryne	1.0+1.0	,, ,,	6.75abc	4.25gh	7.00abc	5.75cd	8.00ab	5.00c
Atrazine	1.5	,, ,,	5.25d	4.50gh	5.75abc	2.50e	7.38ab	2.25d
Atrazine	2.0	,, ,,	3.75e	1.75i	4.50c	1.00e	5.25b	1.00e
Metolachlor+prometryne	0.75+0.75	,, ,,	7.50abc	7.50bcd	7.50ab	8.00ab	8.63ab	8.00ab
Metolachlor plus prometryne	1.0+1.0	,, ,,	6.75abc	5.75efg	7.00abc	6.75bc	8.00ab	7.75ab
Metolachlor plus prometryne	1.25+1.25	,, ,,	7.25abc	6.25def	7.75a	8.25ab	9.25a	8.75ab
Handed weeded	(at 3 & 6WAS)	Control	7.25abc	9.25a	6.25abc	9.00a	7.75ab	9.25a
Weedy check			8.25a	8.75ab	4.70c	4.60d	5.25b	5.25c
S.E. ±	-		0.12	0.12	0.18	0.14	0.13	0.12

1. Crop vigour score base on scale 1-10, where 1 = most vigourous / healthy crop and 10 = crop with poorest vigour/ dead plant.
2. Weeks after sowing
3. Means in the same column of the treatments followed by unlike letters are significantly at 5% level of probability using Duncan Multiple range test (DMRT)

Table 5: Physio-characteristics of soil (0-15cm) of the experimental site

Soil properties	2002/2003	2003/2004
Physical Properties	54	50
Sand (%)	22	30
Silt (%)	24	30
Clay (%)	Sandy Loam	Sandy Loam
Textural Class		
Chemical Properties		
pH in Water	6.40	6.20
pH in 0.1mcacl$_2$	6.20	6.10
Organic Carbon(%)	0.70	0.56
Total Nitrogen (%)	0.38	0.18
Available P (ppm)	10.8	9.02
Exchangeable cation (Cmol/kg)		
K	0.09	0.08
Mg	1.40	1.30
Ca	2.20	2.00
Na	0.28	0.25
CEC	7.40	7.00
Exchangeable acidity (H + Al)	0.10	0.80

Soil sample was analysed at the Soil Science Department IAR/ ABU Zaria.

Conclusion

From the results obtained in this study, it may be concluded that the best three treatments in terms of good weed control and high wheat yield and in the order of declining efficacy were metolachlor plus prometryne at 1.25 + 1.25kg a.i/ha, oxadiazon at 1.0kg a.i/ha and propanil plus bentazon at 2.0 + 1.0kg a.i/ha. These could be adopted for chemical weed control. On the other hand, atrazine and its mixtures have proved phytotoxic to the wheat plant.

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