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Effects of nitrogen and weeding times on performance of maize (*Zea mays* L)

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Article history: Received: October 2014
Accepted: October 2015

Abstract:
A field experiment was conducted in 2011/2012 and 2012/2013at the Demonstration Farm, Faculty of Agriculture, University of Khartoum to investigate the response of maize plants to nitrogen fertilizer levels and weeding time.Treatments were assembled in a randomized complete block design with split plot arrangement replicated four times. Two levels of nitrogen 0N (zero nitrogen) and 2N (80 lbs/fed inurea form) were assigned to the main plots. Eight weed removal timesat 15, 30, 45, 15+30, 15+45, 15+30+45,days after sowing (DAS), weedy and weed free treatmentswere assigned to the sub plots. The results showed thatunrestricted weed growth reduced maize height by 48.9 and 38.4%, shoot dry weight by 74.9 and 73.8% and final yield (ton/ha) by 86.5 and 83.7% in 2011/2012 and 2012/2013 seasons, respectively. Delaying weed removal for 45 DAS decreased plant height by 25.1, 19.9%, and shoot dry weight by 72.1 and 63.8% in 2011/2012 and 2012/2013 seasons and attained yield components cob length, cob weight, grain number/plant, grain weight/plant and final yield (ton/ha) comparable to the weedy check. Nitrogen at 80 lbs/fed increased maize height by 33.1% and 29% ,shoot dry weight by 39.8 % and 55.5% andFinal yield ton/haby 43.5 and 42.7 % in 2011/2012 and 2012/2013 seasons. The interaction between N rates and weed control times had significant effects on maize height, shoot plant dry weight, cob length, cob weight, grain number/plant, grain weight/plant and final yield (ton/ha.) 2N + weeding at 15 + 30 + 45 DAS resulted in plant height comparable to the weed free treatment, and increased yield by 91 and 85.8 % in 2011/2012 and 2012/2013, respectively.

Keywords: Duration of weed infestation, Nitrogen fertilizer, Weed competition, Growth and yield losses, Maize.

Introduction

Maize (*zea mays L)* is a multipurpose cropIn Sudan, used as human food, animal's and poultry feed and industrial product(Bibi *et al.,*(2010). The two greatest factors, following genetics, affecting maize production and yield aresoil fertility and weed management. A number of nutrients are essential for growth and development of maize, among which N is the most important, as it affects growth and production of the crop (Noor *et al.,*2012). The uptake efficiency of nitrogen is dependent upon many factors including tillage system, soil type, amount of nitrogen fertilizer applied and crop – weed competition. Competition for nitrogen between a crop and weeds results in reduced available nitrogen for uptake and utilization by thecrop and oftenalters yield (Knezevic *etal*., 2002). The competitive relationship between maize and weeds is highly depends on many factors including the nitrogen supply, therefore the manipulation of soil fertility is a potential tool for integrated weed management , in addition to that, understanding of the effect of nitrogen (N) on crop – weeds interaction is needed for development of integrated weed management system (Sean *et al.,*2003). Many investigations have been carried out to study the relation between weed control and nitrogenous fertilizers in maize. Khan *et al.,*(2012) reported that the maize – weed competition was greatly influenced by the duration of weed infestation and nitrogen fertilization. Therefore the objective of this study was to quantify the effects of durations of weed interference on maize growth and yield under two levels of nitrogen.

Materials and Methods

The experiment was conducted for two consecutive seasons (2011/2012 and 2012/2013)at the Demonstration (Farm, Faculty of Agriculture, University of Khartoum Sudan, Latitude 15° 40` N and Longitude 32° 23` E,),on heavy clay soil with 48 – 54% clay, 25 – 29% silt and 17 – 25% sand. The pH of the site ranged between 7 and 8. Theexperiment was established using a factorial arrangement of treatments in split-plot randomized complete block design replicated four times. The main plot factor consisted of two levels ofnitrogen 0N (zero nitrogen fertilizer) and 2N (80 lbs). Eight weed removal timescomprised levels of the split plot factor, weeding at 15, 30, 45, 15+30, 15+45, 15+30+45,days after sowing (DAS) in addition to continuous weeding till harvest and un-weeded control. Split-plot size was 2x4m. The experimental sitewas ploughed, harrowed and ridged. Spacing between ridges and holes were 75 and 20 cm, respectively. The commercial variety of maize was sown on the shoulder of the ridge at rate of three to five seeds per hole on 15th October in both seasons; later the seedlingswere thinned to two plants per hole to achieve a density of approximately 16x10^4 plants perhectare. Irrigation was applied at 10-15 days interval depending on temperature and other environmental conditions. At the beginning of tasselling stage, ten plants per plotwere randomly selected to measure the crop growth components including plant height, leaf area index and shoot dry weight. At harvest, ten randomly selectedplants from each treatment were used to record crop yield components, cob length/plant (cm), cob weight/plant (g), grain number per plant, 100 grains weight (g), grain weight per plant (g) and final grain yield ton per hectare.Data were subjected to analysis of variance and means wereseparated using theDuncan's Multiple Range Test

Results and Discussion

Statistical analysis of the data showed that the different treatments had a non-significant effect on maize leaf area index and 100

seeds weight (data not shown). The means of weeding times treatments indicated that unrestricted weed growth reduced maize plant height by 48.9 and 38.4% and shoot weight by 74.9 and 73.8%, compared to that of weedy check treatment, in 2011/2012 and 2012/2013 seasons, respectively. These results are in line with those of Babiker *et al.,*(2013) which indicate that uninterrupted weed growth leads to a significant reduction in maize growth. All the weedingtreatments, irrespective of time, increased maize height and shoot dry weight in both seasons as compared to the weedy check (Table 1). Delaying weed removal for 45 DAS decreased plant height by 25.1 and 19.9% and shoot dry weight by 72.1 and 63.8% as compared to weed free treatment in 2011/2012 and 2012/2013 seasons, respectively (Table 1). The tallest maizeplants and the highest shoot dry weight were recorded under continues hand weeding treatment. Weeding three times 15+30+45 DAS increased plant height by 48.9 and 38.1% and shoot dryweight by 73.4 and 68.7% compared to that of weedy check in 2011/2012 and 2012/2013 seasons, respectively. The observed enhanced plant growth could be attributed, atleast in part, to reductions in intensityof weed competition. These findings,in conformity with those of Khan *et al* (2012), show that hand weeding at 2-6 weeks after sowing increasesmaize growth significantly. The different N levels had a significant effect upon plant height and shoot dry weight. Nitrogen at 80 lbs N/fed increased maize plant height by 33.1% and 29% and shoot dry weight by 39.8% and 55.5% in 2011/2012 and 2012/2013 seasons, respectively (Table 1). The interaction between N rates and weed control times had significant effect on maize plant height and shoot plant dry weight. 2N + weeding at 15+30+45 DAS gave maize plant height comparable to that obtained with 2N + weed free treatment in both seasons (Table 1). These results are in line with those of Noor *et al* (2012) who found that the interaction of N fertilization and weed control might be useful in managing weeds in maize as fertilization promotes growth of the crop and increases its competitiveness make them more competitive against weeds. The minimum plant heights 60 and 83 (cm), and the lighter shoot plant dry weight 16.7 and 19 (g) were observed in case of 0N+ weedy plots in both seasons. It deserve mentioning that in season 2011/2012, weeding at 15 and 45 DAS with or without addition of N gave shoot dry weight comparable to 0N + weedy treatment, this result is in line with thenotion that the critical period of weed competition in cereal crops ranged from 2 to 6 weeks after sowing (Akmal *et al* 2010).Data on weed removal times revealed that delaying weeding time for 45 DAS produced maize cob length (cm), cob weight(g), grain number/plant and grain weight/plant(g) comparable to the weedy check in both seasons (Tables 2 and3).The applied N fertilizer increased cob length by 18.1 and 37.7%, cob weight by 33.5 and 29.5%, grain number/plant by 32.4 and 31.2 % and grain weight/plant by 44.6 and 52. % in 2011/2012 and 2012/2013 seasons respectively (Tables 2 and3) The interaction of the nitrogen fertilizer and weeding times had significant effect on maize yield components cob length, cob weight, grain number/plant, and grain weight/plant. The tallest cob length (16.4 and 15.2 cm), heaviest cob weight (120.4 and 96 g), the highest grain number/plant (316 and 350) and heaviest grain weight/plant(92 and 77 g) were recorded (Tables 2 and3). Final grain yieldwas increased by 43.5 and 42.7 % when adding 80 lbs N/fed. Data on weeding times indicated that unrestricted weed growth reduced maize yieldby 86.5 and 83.7% in comparison with weed free treatment in 2011/2012 and 2012/2013 seasons, respectively (Table4). It is noteworthy that

weeding time at 15 and 45 DAS gave yield comparable to the weedy check (Table 4). The interaction of N levels and weeding times was also noted to be significant upon the final yield tons/ha. The treatments of 0N + weedy check, 2N+ weedy check, 0N + weeding at 15 DAS, 2N + 15 DAS, ON + weeding at 45 DAS. 2N + weeding at 45 DAS gave the minimum yield ton/ha in both seasons (Fig 1 and 2). While the maximum yield was obtained with the 2N + weed free treatment in both seasons. 2N + weeding at 15+30+45 DAS produced considerable increase in maize yield ton/ha 91-85.8 % as compared to 0N + weedy treatment (Fig 1+2), These results are in accordance with Babiker *etal* (2013) who stated that the critical period of weed control in cereals is between 2 – 6 weeks after sowing and he added that keeping the crop weed free within this period protects the crop from weed competition, that leads crop to fully utilize the nutrients principally nitrogen available or added to soil.

Conclusion

Weed competition in maize is primarily responsible for crop growth and yield reductions. Unrestricted weed growth reduced crop height by 38.4 and 48.9%, shoot dry weight by 73.8and 74.9% and yield by 83.7 and 86.5%. Application of 80lbs nitrogen/fed increased crop plant height by 29 – 33.1%, shoot plant dry weight by 55.5 –39.8% and final yield by 42.7 – 43.5%. The interaction between 80lbs nitrogen and weeding three times at 15 + 30 + 45 days after sowing gave plant height comparable to that obtained with 80lbs nitrogen/fed + weed free treatment and resulted in increase of yield by 91–89.5%.

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تأثير التسميد النتروجيني و أوقات إزالة الحشائش علي الذرة الصفراء (*Zea mays L*)

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المستخلص

للتحقق في استجابة محصول الذرة الصفراء لمستويات التسميد النتروجيني و أوقات إزالة الحشائش الضارة أجريت تجربة بالمزرعة التجريبية لكلية الزراعة جامعة الخرطوم في الموسمين 2012/2011 و 2013/2012 باستخدام تصميم القطع المنشقة العشوائي ، مستويين من التسميد 0N (صفر نتروجين) و 2N نتروجين للفدان في شكل يوريا للقطع الرئيسية و ثمانية أوقات لإزالة الحشائش 15، 30، 45، 15+30، 15+45، 15+30+45 يوما بعد الزراعة ، إزالة الحشائش طوال الموسم و عدم الإزالة طوال الموسم للقطع المنشقة . أظهرت النتائج إن عدم إزالة الحشائش في محصول الذرة أدت إلي نقص في طول النبات بمعدل 48,9 –38,4%، الوزن الجاف للنبات بمعدل 74,9 – 73,8% و الإنتاجية طن/هكتار بمعدل 86,5 – 83,7% في الموسميين 2012/2011 و 2013/2012 على التوالي، تأخر إزالة الحشائش إلى 45 يوما بعد الزراعة انقص طول النبات بمعدل 25,1 – 19,9% و الوزن الجاف للنبات بمعدل 72,1 – 63,8% ونتج عنها مكونات إنتاجية طول الكوز، وزن الكوز، عدد البذور للنبات الواحد، وزن البذور للنبات الواحد و الإنتاجية (طن/هكتار) مماثلة لمعاملة عدم إزالة الحشائش طوال الموسم. كما أظهرت النتائج أيضا أن إضافة السماد النتروجيني بمعدل 2Nللفدان أدت إلي زيادة في طول النبات بمعدل 33,1 – 29%، وزن النبات الجاف بمعدل 39,8 – 55,5% و الإنتاجية طن/هكتار بمعدل 43,5 – 42,7%. تفاعل التسميد النتروجيني مع أوقات إزالة الحشائش كان له تأثير معنوي على طول النبات، الوزن الجاف للنبات، طول الكوز، وزن الكوز، عدد البذور للنبات الواحد، وزن البذور للنبات الواحد و الإنتاجية الكلية و المعاملة 2N + إزالة الحشائش ثلاثة مرات 15+30+45 يوما بعد الزراعة أعطت طول نبات مماثل لمعاملة إزالة الحشائش طوال الموسم و نتج عن ذلك زيادة في الإنتاجية طن/هكتار بمعدل 91% في موسم 2012/2011 و بمعدل 85,8 % في موسم 2013/2012.

Table 1: Effect of the nitrogen fertilizer levels and times of weed removal on maize height and shoot dry weight.

Treatments	Plant height (cm)						Shoot dry weight (g)					
	2011/2012			2012/2013			2011/2012			2012/2013		
Weeding times	0N	2N	Means	0N	2N	Means	0N	2N	Means	0N	2N	Means
15 DAS	80 ^{h}	122.4^{e}	101.2^{e}	95^{jk}	121 ^{e}	108^{e}	20.7 ^{h}	32.7 ^{g}	26.7 ^{e}	21 ^{n}	40 ^{i}	30.5 ^{g}
30 DAS	95 ^{fg}	140. 9^{c}	117.9 ^{c}	112 ^{h}	144 ^{c}	128 ^{b}	41.7 ^{f}	54.4 ^{e}	48.1 ^{d}	35 ^{j}	75 ^{d}	55 ^{d}
45 DAS	86 ^{h}	134.8^{cd}	110.4^{d}	93^{k}	140 ^{d}	116.5^{d}	19.7 ^{h}	32.0 ^{g}	25.9 ^{e}	23 ^{m}	46.3 ^{h}	34.7 ^{f}
15+30 DAS	100 ^{f}	157^{b}	128.5^{b}	100 ^{l}	148 ^{b}	124^{c}	53.7 ^{e}	95.4 ^{c}	74.6 ^{c}	40 ^{i}	85.5 ^{c}	62.8 ^{c}
15+45 DAS	82 ^{h}	128.2^{de}	105.1^{de}	80 ^{m}	118 ^{f}	99^{f}	20.7 ^{h}	33.4 ^{g}	27.1 ^{e}	26 ^{l}	50 ^{g}	38 ^{e}
15+30+45DAS	122 ^{e}	164.4^{ab}	143.2^{a}	118^{f}	175 ^{a}	146.5^{a}	65.4 ^{d}	113.4^{b}	89.4 ^{b}	59 ^{f}	101 ^{b}	80 ^{b}
Weed free	120 ^{e}	174.6^{a}	147.3^{a}	115 ^{g}	176 ^{a}	145.5^{a}	69.4 ^{d}	120 ^{a}	94.7 ^{a}	70 ^{e}	121 ^{a}	95.5 ^{a}
Weedy	60 ^{i}	90.4^{fg}	75.2^{f}	83 ^{l}	96 ^{h}	89.5^{g}	16.7 ^{h}	30.7 ^{g}	23.7 ^{e}	19 ^{o}	31 ^{k}	25 ^{h}
Mean	93.13 ^{a}	139.1^{b}		99.5 ^{a}	139.8 ^{b}		38.5 ^{a}	64 ^{b}		30.6 ^{a}	68.7 ^{b}	
SE± (A)	0.86			0.9						0.88		
SE± (B)	255			0.72						0.40		
SE± (A+B)	3.6			1.02						057		

Means followed by the same letters(s) within each column are not significantly different at 5% level of probability according to the Duncan's Multiple Range Test.

Table 2: Effect of the nitrogen fertilizer levels and times of weed removal on maize cob length/plant and cob weight/plant.

Treatments	Cob length (cm)						Cob weight/plant (g)					
	2011/2012			2012/2013			2011/2012			2012/2013		
Weeding times	ON	2N	Means	0N	2N	Means	0N	2N	Means	0N	2N	Means
15 DAS	7.2 ^{ij}	8.3 ^{gh}	7.8 ^{e}	5.9 ^{k}	8.8 ^{e}	7.4 ^{e}	20.9 ^{ij}	30.6 ^{g}	25.8 ^{f}	15 ^{n}	25.8 ^{k}	20.4 ^{g}
30 DAS	10.1 ^{f}	13.7 ^{bc}	11.9 ^{c}	6.4 ^{j}	10 ^{d}	8.2 ^{d}	41.2 ^{f}	56 ^{e}	48.6 ^{d}	30 ^{i}	41.2 ^{f}	35.6 ^{d}
45 DAS	6.9 ^{j}	7.9 ^{i}	7.4 ^{e}	5.5 ^{l}	8 ^{g}	6.8 ^{g}	17.4 ^{jk}	23.5 ^{hi}	20.5 ^{g}	18.4 ^{m}	24.4 ^{l}	21.4 ^{h}
15+30 DAS	12 ^{e}	14.4 ^{b}	13.2 ^{b}	6.9 ^{i}	12 ^{c}	9.5 ^{c}	53.3 ^{e}	65.3 ^{d}	59.3 ^{c}	40.6 ^{g}	58.4 ^{e}	49.5 ^{c}
15+45 DAS	9.2 ^{g}	10.3 ^{f}	9.8 ^{d}	5.6 ^{l}	8.2 ^{f}	6.9 ^{f}	24.6 ^{hi}	39.8 ^{f}	32.2 ^{e}	26.8 ^{j}	38.9 ^{h}	32.9 ^{e}
15+30+45DAS	12.6 ^{de}	16.6 ^{a}	14.6 ^{a}	8.1 ^{f}	14.6 ^{b}	11.4 ^{b}	70 ^{cd}	111.2 ^{b}	90.6 ^{b}	68 ^{d}	89 ^{b}	78.5 ^{b}
Weed free	13.2 ^{cd}	16.4 ^{a}	14.8 ^{a}	8.7 ^{e}	15.2 ^{a}	11.9 ^{a}	74 ^{c}	120.4 ^{a}	97.2 ^{a}	72 ^{c}	96 ^{a}	84 ^{a}
Weedy	6.8 ^{j}	8.1 ^{h}	7.5 ^{e}	5.3 ^{m}	7.6 ^{h}	6.5 ^{g}	13.9 ^{jk}	28.2 ^{hg}	21.1 ^{g}	10.2 ^{o}	24.4 ^{l}	17.3 ^{h}
Mean	9.75 ^{a}	11.9 ^{b}		6.6 ^{a}	10.6 ^{b}		39.5 ^{a}	59.4 ^{b}		35.1 ^{a}	49.8 ^{b}	
SE± (A)	0.08			0.11			0.69			0.65		
SE± (B)	0.22			0.03			1.2			0.11		
SE± (A+B)	0.31			0.05			1.7			0.15		

Means followed by the same letters(s) within each column are not significantly different at 5% level of probability according to the Duncan's Multiple Range Test.

Table 3: Effect of the nitrogen fertilizer levels and times of weed removal on maize grain number and grain weight/plant.

Treatments	Grain number						Grain weight /plant(g)					
	2011/2012			2012/2013			2011/2012			2012/2013		
Weeding times	0N	2N	Means	0N	2N	Means	0N	2N	Means	0N	2N	Means
15 DAS	62 ^{i}	82 ^{h}	72 ^{e}	81 ^{k}	102 ^{hi}	91.5 ^{e}	8.2 ^{i}	13 ^{fgh}	10.6 ^{f}	7 ^{i}	13 ^{g}	10 ^{e}
30 DAS	125 ^{g}	186 ^{e}	155.5^{d}	131 ^{g}	206 ^{e}	168.5^{d}	16 ^{f}	34 ^{d}	25^{d}	13 ^{g}	35 ^{de}	24 ^{d}
45 DAS	59 ^{ij}	78 ^{h}	68.5 ^{ef}	72 ^{l}	98 ^{ij}	85 ^{f}	9 ^{hi}	11 ^{hi}	10^{f}	7 i	12 ^{g}	9.5 ^{e}
15+30 DAS	161 ^{f}	242 ^{c}	201.5^{c}	172^{f}	262 ^{h}	217 ^{c}	25 ^{e}	48 ^{c}	36.5 ^{c}	21 ^{f}	47 ^{l}	34 ^{c}
15+45 DAS	62 ^{l}	86 ^{h}	74 ^{e}	82 ^{k}	106 ^{h}	94 ^{e}	12 ^{hij}	16 ^{fg}	14^{e}	8 ^{hi}	14 ^{g}	11 ^{e}
15+30+45DAS	196 ^{e}	300 ^{b}	248 ^{b}	210 ^{e}	320 ^{b}	265 ^{b}	46 ^{c}	81 ^{b}	63.5^{b}	32 ^{e}	66 ^{b}	49 ^{b}
Weed free	208 ^{d}	316 ^{a}	262^{a}	235 ^{d}	350 ^{a}	292.5^{a}	45 ^{c}	92 ^{a}	68.5 ^{a}	37 ^{d}	77 ^{a}	57 ^{a}
Weedy	50^{j}	76 ^{h}	63 ^{f}	76 ^{l}	96^{j}	86 ^{f}	8 ^{i}	11 ^{hi}	9.5 ^{f}	7 ^{i}	11 ^{gh}	9 ^{e}
Mean	115.4^{a}	170.8^{b}		132.4^{a}	192.5^{b}		21.2 ^{a}	38.3 ^{b}		16.5 ^{a}	34.4 ^{b}	
SE± (A)	2.6						0.88					
SE± (B)	2.5						089					
SE± (A+B)	3.5						1.26					

Means followed by the same letters(s) within each column are no significantly different at 5% level of probability according to the Duncan's Multiple Range Test.

Table 4: Effects of the nitrogen fertilizer levels and times of weed removal on maize final grain yield ton/ ha in 2011/2012 and 2012/2013 seasons

Treatments						
	2011/2012			2012/2013		
Weeding times	0N	2N	Means	0N	2N	Means
15 DAS	0.49 ^{h}	0.79 ^{fg}	0.64 ^{f}	0.60 ^{i}	1.05 ^{g}	0.83 ^{e}
30 DAS	0.96 ^{f}	2.01 ^{d}	1.49 ^{d}	1.05 ^{g}	2.75 ^{de}	1.90 ^{d}
45 DAS	0.66 ^{gh}	0.60 ^{gh}	0.63 ^{f}	0.55 i	0.95 ^{g}	0.75 ^{e}
15+30 DAS	1.50 ^{e}	2.89 ^{c}	2.20 ^{c}	1.65 f	3.80 ^{c}	2.73 ^{c}
15+45 DAS	0.70 ^{gh}	0.93 ^{f}	0.82 ^{e}	0.65 ^{hi}	1.10 ^{g}	0.88 ^{e}
15+30+45DAS	2.80 ^{c}	4.87 ^{b}	3.84 ^{b}	2.50 ^{e}	5.25 ^{b}	3.88 ^{b}
Weed free	2.80 ^{c}	5.50 ^{a}	4.15 ^{a}	2.85 ^{d}	6.10 ^{a}	4.48 ^{a}
Weedy	0.48 ^{h}	0.64 ^{gh}	0.56 ^{f}	0.55 ^{i}	0.90 ^{gh}	0.73 ^{e}
Mean	1.3 ^{a}	2.3 ^{b}		1.30 ^{a}	2.74 ^{b}	
SE± (A)	0.11			0.06		
SE± (B)	0.10			0.14		
SE± (A+B)	0.15			0.19		

Means followed by the same letters(s) within each column are no significantly different at 5% level of probability according to the Duncan's Multiple Range Test.

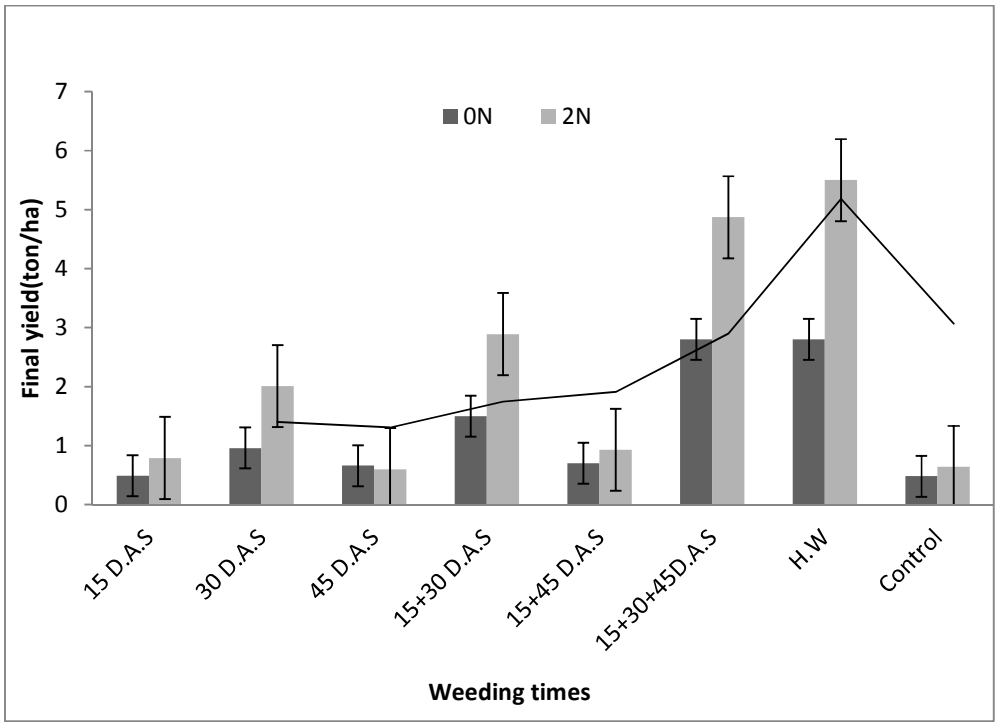

Fig 1: Effects of the interaction of nitrogen fertilizer levels and times of weed removal on maize final grain yield (ton/ ha)during season 2011-2012.

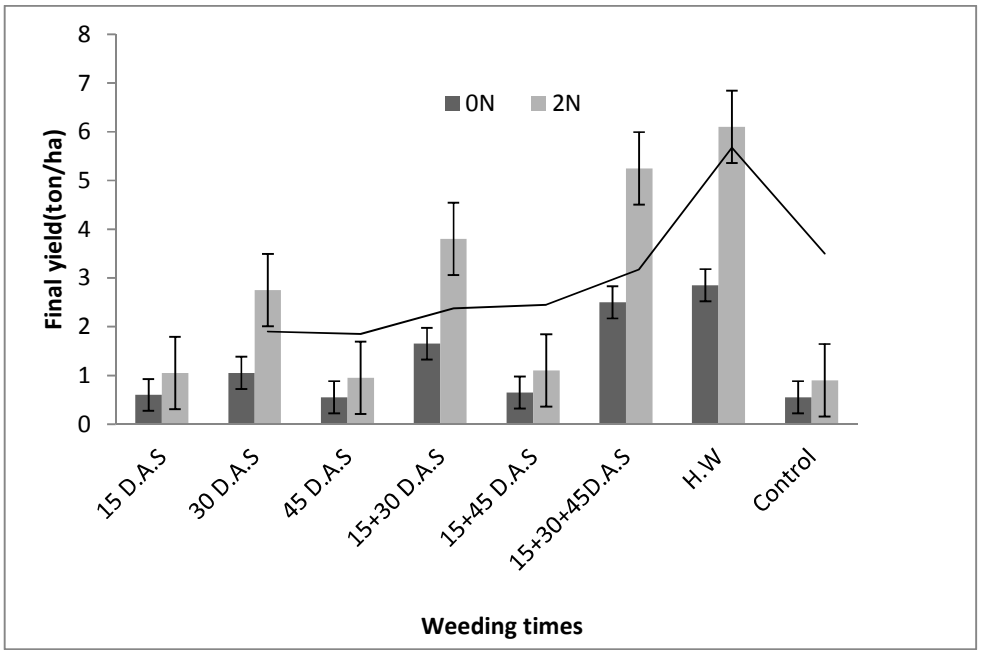

Fig 2: Effects of the interaction of nitrogen fertilizer levels and times of weed removal on maize final grain yield (ton/ ha) during season 2012-2013