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EVALUATION OF HERBICIDES FOR WEED CONTROL EFFICACY IN GROUNDNUTS (*ARACHIS HYPOGAEA* L.) IN THE GUINEA SAVANNAH ZONE OF GHANA

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Abstract

Groundnut (Arachis hypogaea L.) is the most popular leguminous crop cultivated for food and cash in the Guinea savannah zone of Ghana. A field experiment was conducted to study the effect of pre-emergence and post emergence herbicides for weed control in groundnuts during the 2011 and 2012 cropping seasons. The study determined the most suitable combination of herbicide with or without hand weeding that could enhance efficient weed control and promote yield and yield components in groundnuts. Thirteen weed control treatments were laid out in randomized complete block design with four replications. Percent mean weed index, which determines the reduction in crop yield due to the presence of weeds and an ideal parameter to judge treatment weed control effectiveness, was least with the application of: pendimenthalin at 0.15kg a.i./ha plus one hand weeding at 4WAP, haloxyfop at 0.03kg a.i./ha plus one hand weeding 7WAP, propaquizafop at 0.02kg a.i./ha at 4WAP plus one hand weeding at 7WAP and also bentazon at 0.14kg a.i./ha at 4WAP plus one hand weeding at 7WAP. The same treatments gave weed control efficiencies of 78 to 85% comparable to the accepted farmer control practice of twice weeding at 3 and 6 weeks after planting. Combination of pre- and post-emergence herbicides as a weed control package in groundnuts does not appear advantageous. Season-long weed infestation reduced pod yield by 36% in 2011 and 76% in 2012. Summed dominance ratio of weed species amplified prevalence of broadleaves such as Ageratum conyzoides (L), Commelina africana (Linn), Corchorus olitorius (Linn), Hyptis suaveolens (Poit) and Ludwigia abyssinica (A. Rich). Season-long unweeded entries gave pod yield loss of 43 to 69%.

Keywords: ***Herbicides, Groundnut, Pod Yield, Weed Control Efficiency, Weed Index.***

INTRODUCTION

Groundnut or peanut (*Arachis hypogaea* L.) is an annual leguminous crop widely cultivated in the Guinea savannah zone of Ghana due to its adaptation to semi-dry climatic conditions and its ability to grow relatively well on infertile soils (Kaleem, 1990; Gascho and Davis, 1995). The crop provides a major source of protein to human diets, and its vegetable protein and haulm, which remain green through harvest, greatly improves their value as livestock feed in Ghana (Marfo, 1997). Vegetable oil is extracted from the seed for various uses including for consumption and industrial products (FAO, 1986). The crop plays a significant role in soil fertility restoration as a result of high atmospheric nitrogen fixation (Onwueme and Sinha, 1999). Sustainable cultivation of the crop in the savanna ecology could therefore be of multiple benefits for food security in both rural and urban livelihoods in the West African region (Schilling and Misari, 1992; SRID, 2004) and mitigation of climate change.

Yield loss in groundnuts could be attributed to erratic distribution of rainfall, lack of high yielding varieties, low soil fertility and poor knowledge of effective disease and weed management (Cassanova and Solorzano, 1991; Saleh, 1992; Abudulai et al., 2007). The relatively slow initial vegetative growth of groundnut and the long time taken for canopy close-up enhances the susceptibility of the crop to early season and protracted weed interference (Akobundu, 1987; Subrahmaniyan et al., 2002). According to Singh and Yadav (2012), weeds seriously reduce the yield of crops through competition for sunlight, soil nutrients and carbon-dioxide and oxygen. Efficient and appropriate use of herbicides could, however reduce drudgery to meet target timing of weed control (Schilling, 2002). Combinations of pre-plant incorporated or pre-emergence herbicides currently registered for use in groundnut have not shown any crop injury (Wilcut et al., 1995). Co-application of post-emergence herbicides with efficacy against dicotyledonous weeds and sedges broadens the spectrum of control (Jianhua et al., 1995; Wilcut et al., 1995). Herbicides look better than any other method of weed control because of their performance in decreasing weed density and competition, easy usage, and economic low cost and less work force. Gill (1982) noted that herbicides provided about 30% more efficient weed control to manual hoeing/hand weeding. Parasuraman (2000) found the application of pendimethalin at 1.5-2.0 l/ha) or fluchloralin at 1.0-1.5 l/ha supplemented with hand-weeding resulted in significant reduction in weed population and weed dry matter but increased crop yield in groundnut. Silva (2003) reported phenoxaprop-p-ethyl applied post-emergence at 80 kg/ha, provided effective control of grasses. However, Fadayomi and Olofintoye (2005) reported that herbicides could be phytotoxic if not used within a certain dose range. New herbicides continue to flood the Ghanaian market, necessitating the need for evaluation for best-bet acceptable and safe dose range recommendations for adoption by farmers. The objectives of this paper were to determine the most suitable combination of herbicides and/or hand weeding that could enhance weed control efficiency, reduce weed index and promote pod yield and yield components of groundnuts.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the research field of the Savannah Agricultural Research Institute (SARI) at Akukayili near Tamale in the Guinea savannah zone of Ghana from June to September in 2011 and 2012. The rainfall pattern is unimodal with a mean annual of 1200 mm. The soil type is sandy loam. The vegetation in the area is largely grassland with sparsely distributed short trees and shrubs. The relative humidity is characterized by a maximum monthly value of 84% during the raining season and 50% during the dry season (SARI, 2004). Temperature distribution is uniform with mean monthly minimum of 23.4^0C and maximum of 34.5^0C.

Experimental design and materials

The experiment was a single factor trial laid out in randomized complete block design, consisting of thirteen treatments with four replications. The groundnut cultivar 'Chinese' of 90 days maturity period was planted at an inter and intra-row spacing of 50cm x 20cm respectively on plots of 8m by 2.5m. One seed/hill was sown at a soil depth of about 5cm in the second week of June in both seasons. Table of results indicated the herbicide entries sprayed using a knapsack sprayer calibrated to discharge 200l of water per/ha.

Table 1. Common name, trade name, classification and target weed flora of tested herbicides

Common Name	Trade Name	Classification	Target weeds
Pendimenthalin	Stomp	Pre- and Early post-emergence	Annual grasses and broadleaves
Haloxyfop	Gallant Super /Verdict	Pre- and Early post-emergence	Annual and perennial Grasses
Propaquizafop	Agil	Post-emergence	Annual and perennial grasses
Bentazon	Basagram	Post-emergence	Broadleaves

DATA COLLECTION

Climatic data on rainfall, relative humidity and temperature for 2011 and 2012 were recorded. Canopy spread was measured within a mean of 1 m^2 quadrat per three quadrat-placements per plot at 3, 6 and 9WAP. Nodulation count of five border plants per plot were recorded at 40 DAP. Weed density score was taken at 6, 9 and 12WAP, using three 1m^2 quadrat samplings per plot and the prevalent species identified. Weed density was scored on the scale of 0-4, where 0 = 0 occurrence of a weed species per 1 m^2, 1 = 1 weed species per 1 m^2, 2 = 2-5 weed species per 1 m^2, 3 = 6-19 weed species per 1 m^2 and 4 ≥ 20 or more of the weed species per 1 m^2. Weed occurrence using the summed dominance ratio (SDR) was calculated as: $\frac{1}{2}$ $(f/\sum f + d/\sum d) \times 100\%$. Weed biomass per 1$m^2$ quadrat was taken at 9 WAP and harvest, using three quadrat samples per plot and weeds harvested were oven- dried at 80°C for 48 hours before weighing. Percent weed index (WI%) was determined as the reduction in crop yield due to the presence of weeds i.e. {((Yield of weed free-check - Yield of treatment)/Yield of weed-free check) x 100}, which is an ideal parameter to judge the weed control effectiveness of treatments. Percent weed control efficiency (WCE%) was calculated as: {((Dry matter production of control treatment - Dry matter production of treated plot)/Dry matter production of control treatment) x 100}.

Number of pods per plant was taken by counting fully developed pods per the five tagged plants. Haulm yield at harvest was measured by harvesting crop stands from the middle four 8 m long rows of each plot (net plot) and oven-dried as described above. Pod yield was determined after harvesting crop stands from the net plot, sun-dried and weighed.

RESULTS AND DISCUSSION

Effect of experimental site weather conditions of trial performance

Growing season precipitation, relative humidity and temperature characteristics of the experimental site depicted higher amounts of rainfall in 2011 than 2012 which could have probably influenced the variance in performance of the crop in the two years (Fig. 1). The main contrast in amount of rainfall was in August which, reduced pod formation and pod filling in 2012. Otherwise, rainfall distribution was similar in both years and the relative humidity and temperature appeared comparable.

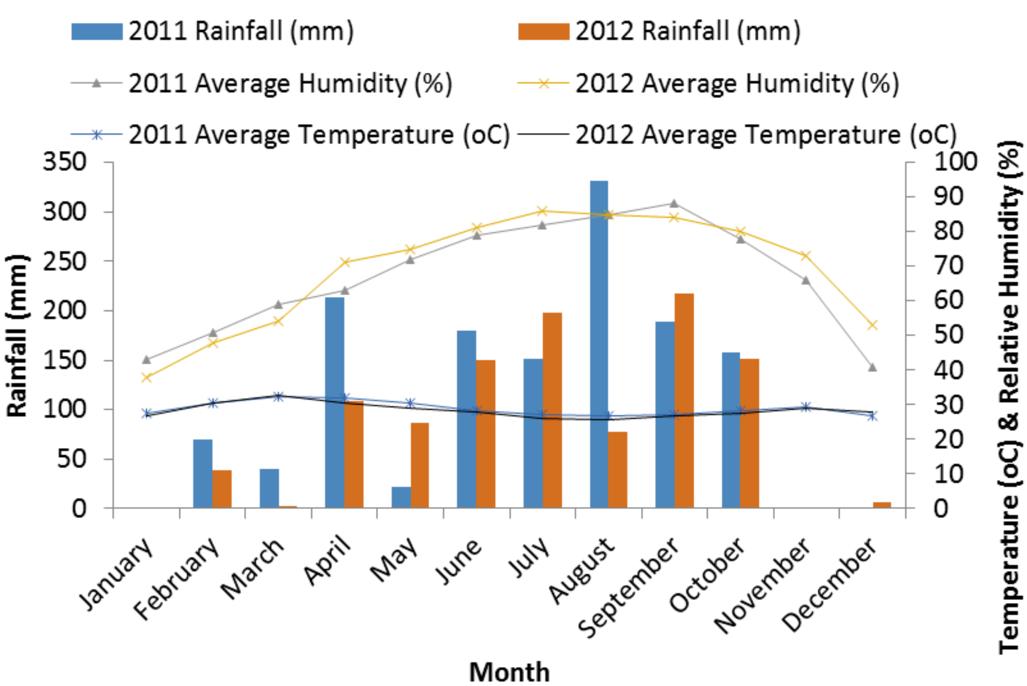

Fig. 1. Rainfall, relative humidity and temperature characteristics of the experimental site during the 2011 and 2012 cropping years.

Canopy spread

Canopy spread of groundnut was not adversely affected by herbicide weed control relative to the farmer control of twice hand weeding in both cropping seasons of 2011 and 2012. Differences in performance of herbicide weed control on the parameter were however observed ($p<0.001$) at 6 and 9WAP compared with the weedy check; as the farmer method generally in similarity with the herbicide application enhanced canopy spread (Table 2). Apparently the application of either the pre-emergence or post-emergence herbicides or both and twice hand weeding afforded the crop less weed competition as weed seed germination and/or seedling development at early stage of crop growth was suppressed below critical damage. Kondap et al. (1989) noted no variation in pod yield with application of pendimethalin at 1.5 kg a.i./ha or hand weeding at 15 and 35 days after sowing.

Table 2: Effect of herbicide weed control treatments on canopy spread at different crop growth stages in groundnut

Treatments	Canopy spread (cm)					
	2011			**2012**		
	WAP			WAP		
	3	6	9	3	6	9
Pendimenthalin+HW@4WAP	13.88	28.68	47.82	16.17	29.97	40.72
Haloxyfop @4WAP + 1HW	15.23	31.99	44.48	13.92	23.53	32.29
Propaquizafop @4WAP +1HW	13.75	29.54	39.51	14.89	28.9	41.61
Bentazon @4WAP + 1HW	13.83	24.64	39.85	14.51	28.16	33.78
Pendimenthalin + Haloxyfop 4WAP	13.5	33.38	51.43	15.01	27.65	36.06
Pendimenthalin + Propaquizafop @4WAP	13.65	22.65	36.91	15.05	27.64	36.34
Pendimenthalin+ Bentazon @4WAP	13.35	34.26	51.28	15.67	30.45	41.41
Pendimenthalin @4WAP	14.2	32.47	48.6	14.77	29.21	40.24
Haloxyfop @4WAP	13.7	20.44	31.01	15.13	27.64	37.73
Propaquizafop @4WAP	13.9	26.8	36.48	15	26.32	33.78
Bentazon @4WAP	15.98	35.8	51.82	14.96	26.09	37.06
Weedy Check	13.95	23.39	30.47	14.8	24.7	32.67
Weeding @ 3&6WAP	14.15	31.43	50.7	14.84	26.32	39.92

SED	1.046	2.143	3.313	0.86	2.045	3.372
CV%	10.5	10.5	10.9	8.1	10.5	12.6

Nodulation Count

Mean nodulation count varied significantly with herbicide weed control ($p<0.01$) as weedy check suppressed the parameter, but pendimenthalin at 0.15kg a.i/ha plus one hand weeding at 4WAP and haloxyfop at 0.03kg a.i/ha at 4 WAP plus one hand weeding at 7WAP supported high number of nodules per plant similar to farmer practice (Fig. 2). Season-long uncontrolled weed growth reduced nodulation by 57%.

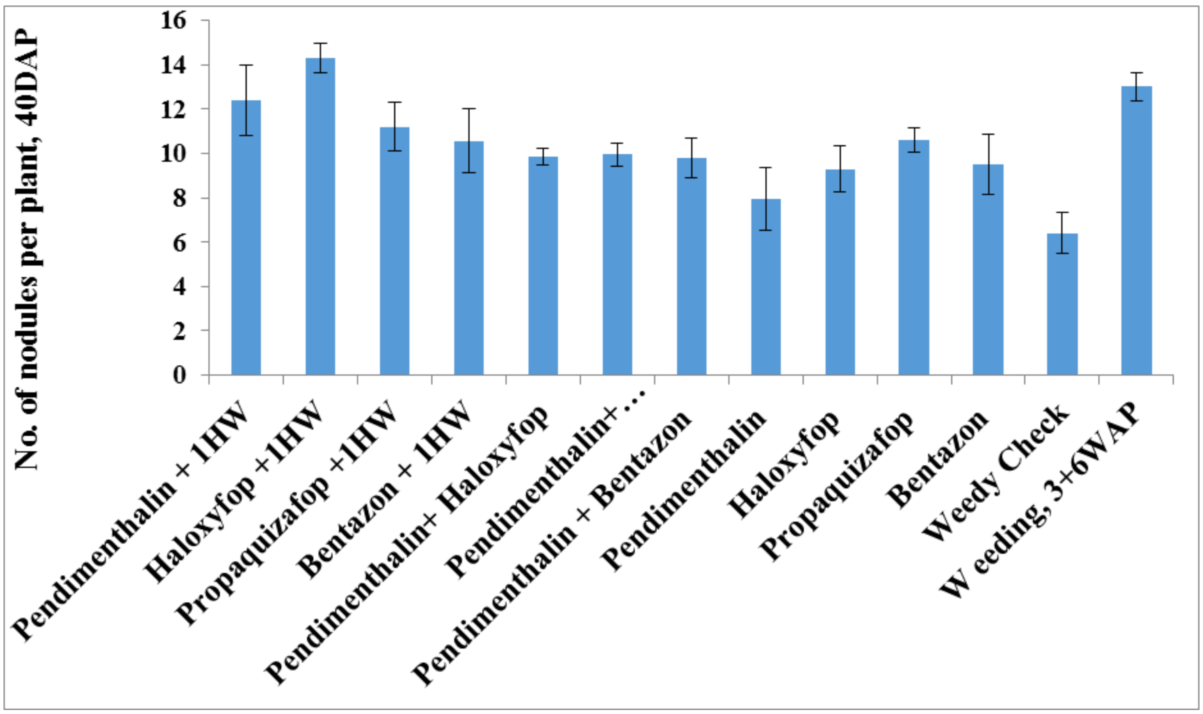

Fig. 2. Effect of weed control treatments on mean nodulation count in 2011 and 2012. Bar represents SEM

Weed Biomass

Weed biomass varied significantly ($p<0.001$) with herbicide treatments in 2011 and 2012 in which, application of pendimenthalin at 0.15kg a.i/ha plus one hand weeding at 4WAP, haloxyfop at 0.03kg a.i/ha plus one hand weeding 7WAP, propaquizafop at 0.02kg a.i/ha at 4WAP plus one hand weeding at 7WAP and also bentazon at 0.14kg a.i/ha at 4WAP plus one hand weeding at 7WAP (Fig. 3a,b) consistently were equally outstanding as the farmer practice in reducing weed biomass relative to the weedy check. Notably, the herbicide treatments required supplementary hoeing to maximize weed control.

These results suggest that application of these herbicides might have prevented or suppressed the germination of susceptible weed species and reduced the growth of germinated weeds through their specific herbicidal action (Muzik, 1970; Mahadi et al., 2006).

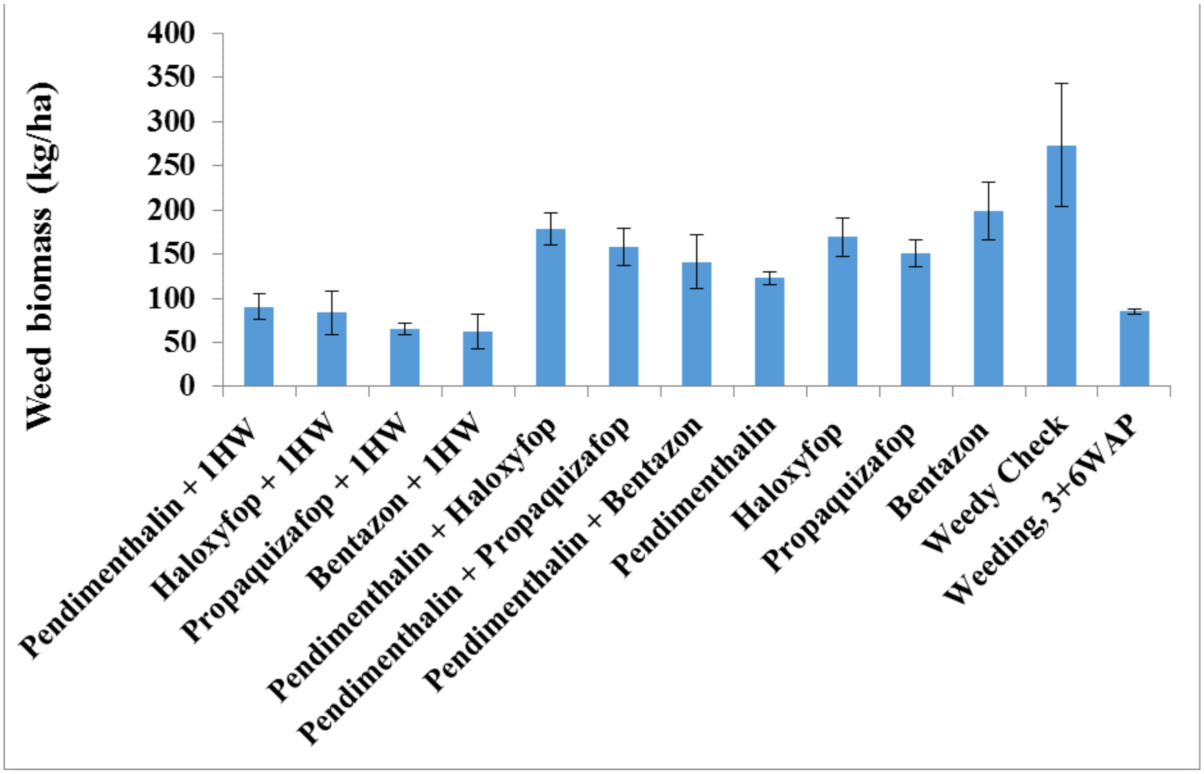

Fig. 3a. Effect of weed control treatments on weed biomass in 2011. Bar represent SEM.

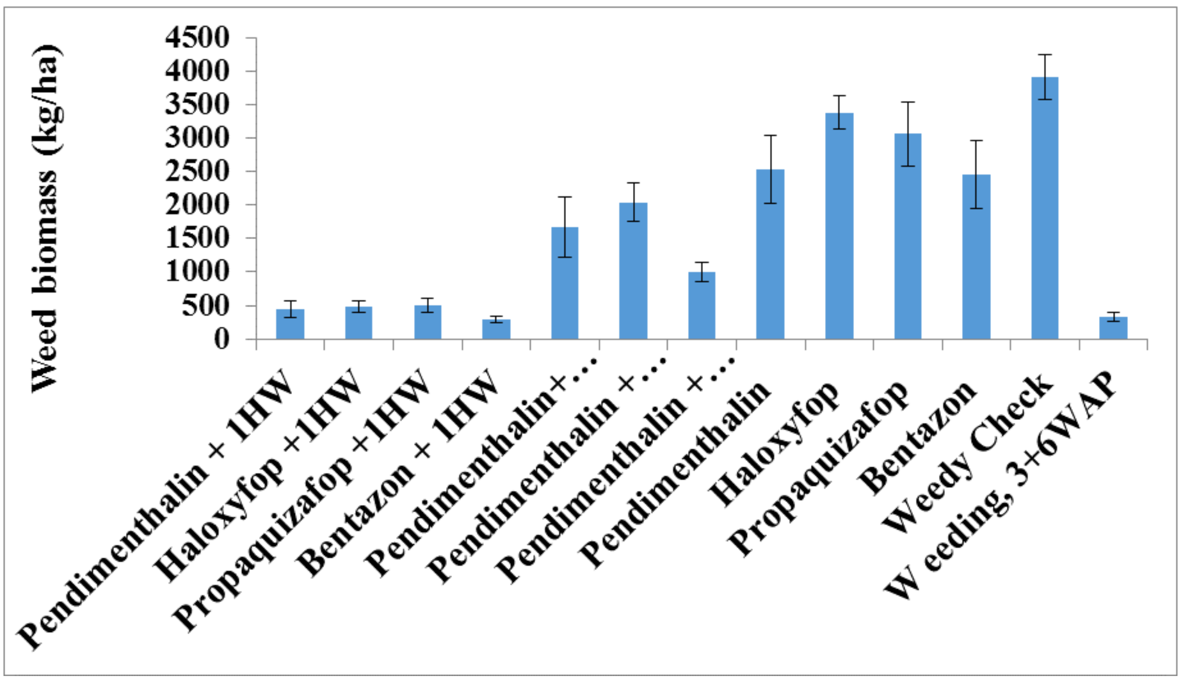

Fig. 3b. Effect of weed control treatments on weed biomass in 2012. Bar represent SEM.

Haulm yield

Herbicide weed control significantly determined ($p<0.001$) haulm yield of groundnuts in 2011 and 2012 but with some variations in the two years. In 2011, farmer practice gave the highest haulm yield, whilst treatments which gave at least 90% of the check were: propaquizafop at 0.02kg a.i/ha at 4WAP plus one hand weeding at 7WAP, haloxyfop at 0.03kg a.i/ha at 4WAP plus one hand weeding at 7WAP, pendimenthalin at 0.15kg a.i/ha plus one hand weeding at 4WAP and bentazon at 0.14kg a.i/ha at 4WAP plus one hand weeding at 7WAP (Fig. 4a). In 2012, treatments that gave at least 90% of the performance of the hand weeded control were: pendimethaline alone, pendimenthaline plus bentazon, pendimenthaline plus haloxyfop, propaquizafop plus one hand weeding, haloxyfop plus one hand weeding, and propaquizafop alone (Fig. 4b).

Variations in haulm yield among treatments could probably be due to differences in weed control efficiencies of the herbicides in reducing the build-up of weed density and consequential competition for crop growth factors which promoted crop growth and establishment. Marfo (1997) reported the potential haulm yield of some peanut cultivars to be in the range of 2180 to 3000 kg/ha with grain yield of 760 to 6200 kg/ha were due to good weed control.

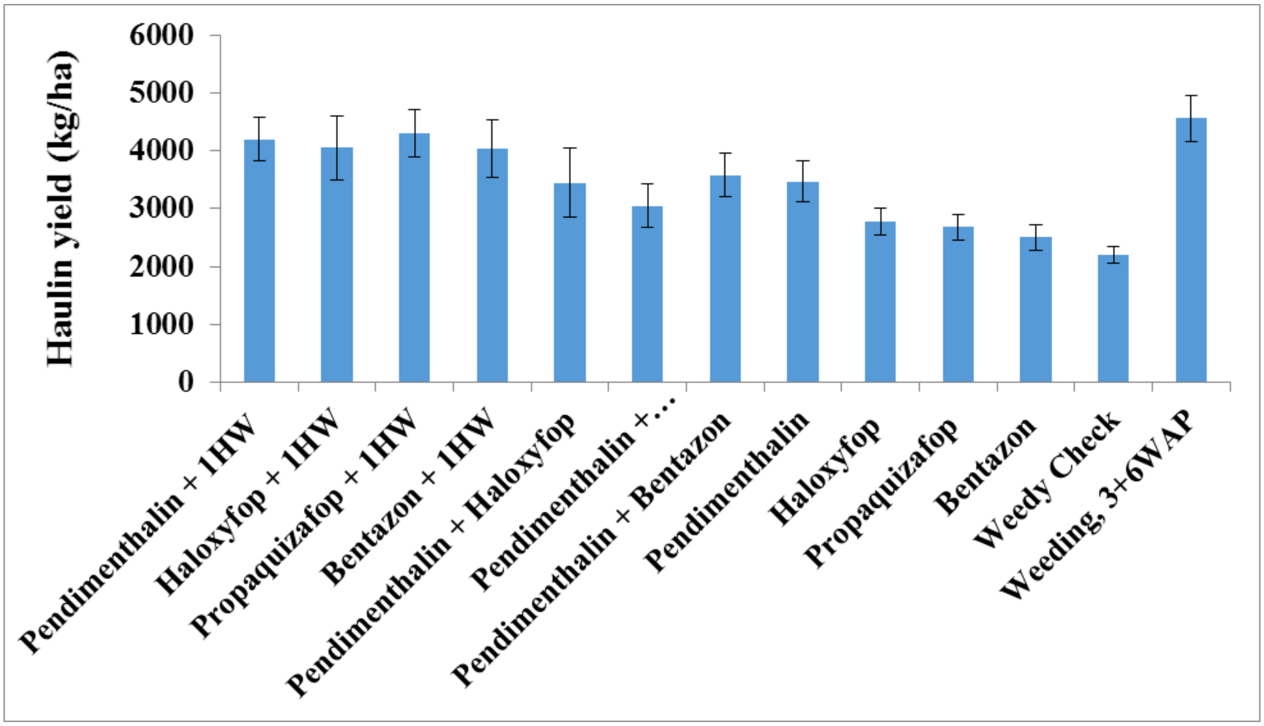

Fig. 4a. Effect of weed treatments on haulm yield in 2011. Bars represent SEM.

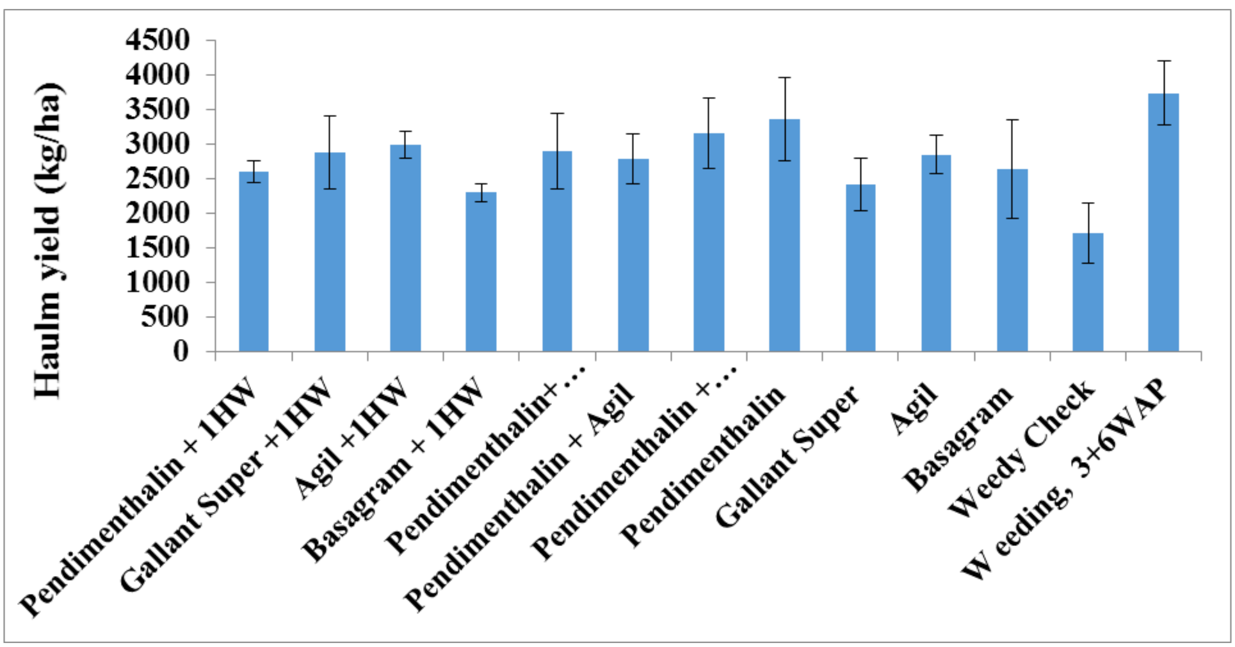

Fig. 4b. Effect of weed treatments on haulm yield in 2012. Bars represent SEM.

Pod yield

Pod yield was significantly ($p<0.05$) modified in 2011 and 2012 due to herbicide weed control treatments. In 2011, hand weeded control supported the highest pod yield of 4500 kg/ha but pendimenthalin at 0.15kg a.i/ha plus one hand weeding at 4WAP, haloxyfop at 0.03kg a.i/ha plus one hand weeding 7WAP, propaquizafop at 0.02kg a.i/ha at 4WAP plus one hand weeding at 7WAP, bentazon at 0.14kg a.i/ha at 4WAP plus one hand weeding at 7WAP and pendimenthalin at 0.15kg a.i/ha plus haloxyfop gave at least 90% of the maximum yield (Fig. 4a). In 2012, except Gallant super, herbicide treatments supported pod yield comparable to the hand weeded control, with maximum pod yield attained with the application of pendimenthaline plus Gallant supper (Fig. 4b).

The results indicated that the herbicides in combination with one hand weeding application offered higher weed control efficiency as well as higher groundnut pod yield. Patra and Naik (2001) also reported increased pod number per plant due to herbicide control treatments. Rajsingh and Patel (1991) noted that removal of weeds up to 60 days after sowing resulted in the highest groundnut pod yields of 1.42 to 1.46 t per ha compared to un-weeded control. Hiremath et al. (1997) found that pre-emergence application of pendimethalin at 1.5 kg a.i per ha and oxyfluorfen at 0.2 kg a.i per ha effectively checked both C3 and C4 weeds thereby exhibiting highest weed control efficiency and recorded lowest weed index thus improving the pod yields in groundnut. It was observed in our trial that uncontrolled weed growth resulted in 43% and 69% loss in pod yield in 2011 and 2012 respectively. Weed biomass gave negative correlation coefficients with pod yield while canopy spread correlated positively with pod yield.

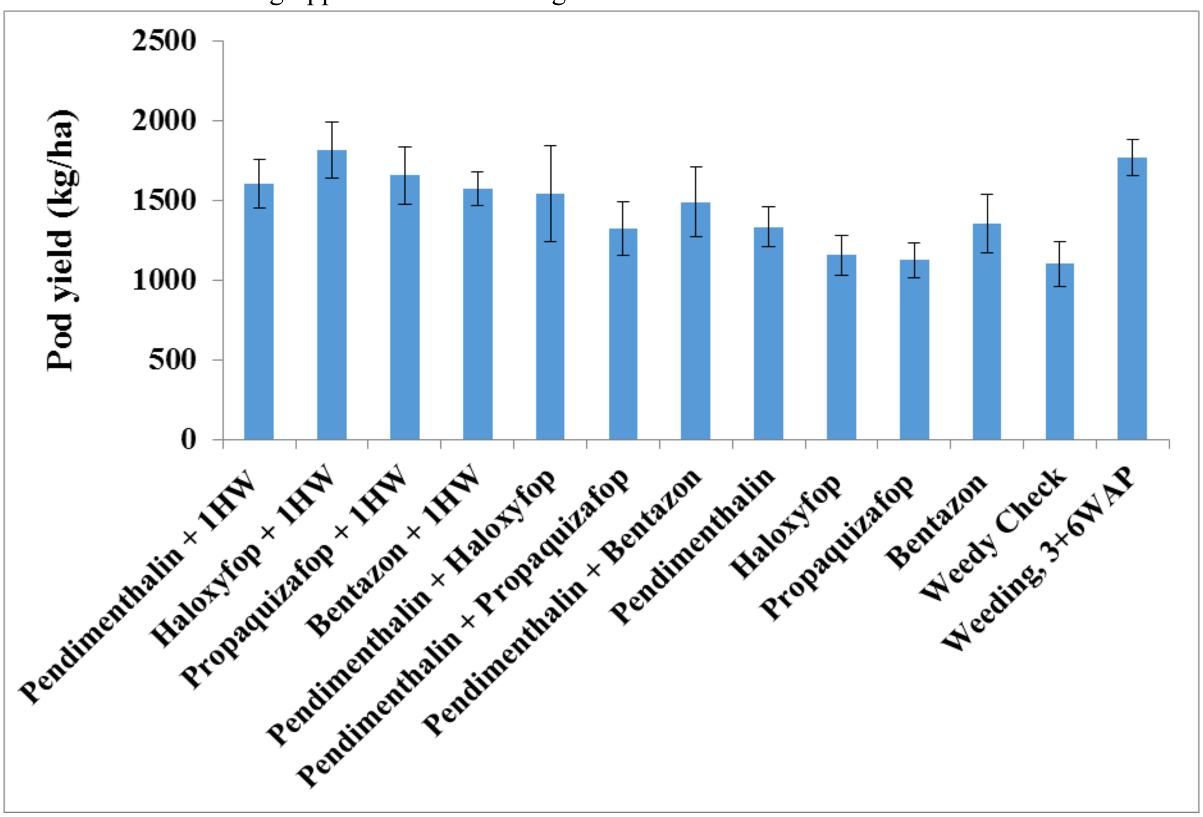

Fig. 5a. Effect of weed control treatment on pod yield kg/ha in 2012. Bars represent SEM

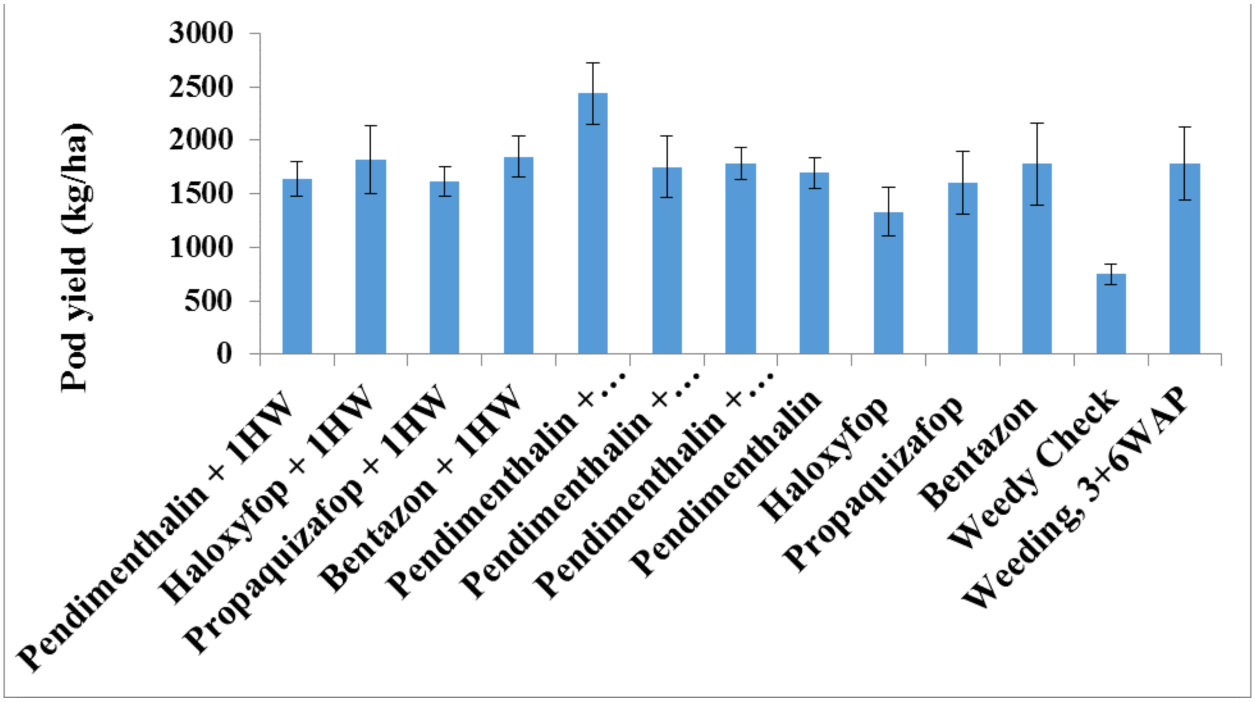

Fig. 5b. Effect of weed control treatment on pod yield in 2012. Bars represent SEM.

Weed density

Eighteen weed species occurred in the two years with mean density range of 1.6 - 12%; with broadleaves > grasses > sedges in dominance (Table 2). *Ageratum conyzoides* (Linn), *Bracharia lata* (Shumach), *Corchorus olitorius* (Linn), *Cyperus esculentum* (Linn), *Cyperus rotundus* (Linn), *Dactylocterium aegyptium* (Linn), *Hyptis suaveolens* (Poit), *Kyllinga erecta* (Schumach.Var.), *Ludwigia decurrens* (Walt. syn) and *Paspalum scrobiculatum* (Linn) were of high occurrence. Annual weeds such as *Commelina Africana* (Linn), *Ipomoea hederacea* (P.Beauv), *Kyllinga erecta* (Schumach.Var.) and *Cyperus esculentus* (Linn), could have perennial lifespan under favourable moisture conditions, making their control more difficult. However, *Cyperus rotundus* (Linn) is most difficult to control due to the presence of perennating propagules of tubers and rhizomes. The spectrum of weed flora was similar to the earlier report of Dzomeku et al. (2009) and could be a reflection of the soil seed bank of the location.

Table 3: Mean occurrence of weed species at trial site in 2011 and 2012 cropping seasons.

Weed species	**Weed density SDR (%)**			**Life Span**
	60 DAP	**90 DAP**	**Mean**	
Broadleaves	-	-	-	
Ageratum conyzoides (Linn)	4.7	6.53	5.6	A
Amaranthus spinosus(Linn)	4.7	-	2.4	A
Cleome viscose L.	4.8	-	2.4	A
Commelina africana (Linn)	3.1	5.8	5.2	A/P
Corchorus olitorius (Linn)	17.9	3.45	10.7	A

Euphorbia hirta (Linn)	3.6	3.10	3.4	A
Hyptis suaveolens (Poit)	-	17.7	8.9	A
Ipomoea hederacea (P.Beauv)	-	3.1	1.6	A/P
Ludwigia decurrens (Walt. syn)	3.6	6.5	5.1	A
Mitracarpus villosus (Sw.Dc.)	3.6	4.8	4.2	A
Phyllantus amarus (Schum. thom)	-	4.86	2.4	A
Senna obtusifolia (Poit)	2.4	-	1.2	A
Grasses	-	-	-	
Paspalum scrobiculatum (Linn)	15.7	8.9	12.2	A
Bracharia lata (Shumach)	10.2	8.6	9.4	A
Dactyloctenium aegyptium (Linn)	13.2	9,6	11.4	A
Sedges	-	-	-	
Cyperus rotundus (Linn)	12.3	7.2	9.8	P
Cyperus esculentus (Linn)	10.8	6.9	8.9	A/P
Kyllinga erecta (Schumach.Var.)	6.6	9.7	8.2	A/P

Weed index

The lowest weed index was attained with the farmer practice; but five treatments gave acceptable mean weed index under of up to 25% (Table 3). These treatments were applications of: pendimenthalin at 0.15kg a.i/ha plus one hand weeding at 4WAP, haloxyfop at 0.03kg a.i/ha plus one hand weeding 7WAP, propaquizafop at 0.02kg a.i/ha at 4WAP plus one hand weeding at 7WAP and also bentazon at 0.14kg a.i/ha at 4WAP plus one hand weeding at 7WAP and pendimenthalin plus haloxyfop applied at 4WAP. Percent weed index determines the reduction in crop yield due to the presence of weeds, which is an ideal parameter to judge the weed control effectiveness of treatments.

Table 3: Effect of weed control treatments on weed index (%) from 2011-2012.

Weed control treatments	Weed Index (%)		
	2011	2012	Mean
Pendimenthalin+HW@4WAP	8.0	32.7	20.4
Haloxyfop @4WAP + 1HW	11.2	25.3	23.9
Propaquizafop@4WAP +1HW	5.7	33.9	22.7

Bentazon@4WAP + 1HW	11.4	24.2	23.5
Pendimenthalin + Haloxyfop 4WAP	24.4	0	24.4
Pendimenthalin + Propaquizafop @4WAP	33.1	28.2	47.2
Pendi menthalin+ Bentazon @4WAP	21.5	26.8	34.9
Pendimenthaline Only @4WAP	24	30.5	39.3
Haloxyfop @4WAP	39.3	45.3	62.0
Propaquizafop@4WAP	41.1	34.4	58.3
Bentazon @4WAP	45.2	27	36.1
Weedy Check	42.9	69.2	56.1
Weeding @ 3&6WAP	0	26.9	13.5

Weed control efficiency

Applications of pendimenthalin at 0.15kg a.i/ha plus one hand weeding at 4WAP, haloxyfop at 0.03kg a.i/ha plus one hand weeding 7WAP, propaquizafop at 0.02kg a.i/ha at 4WAP plus one hand weeding at 7WAP and also bentazon at 0.14kg a.i/ha at 4WAP plus one hand weeding at 7WAP (Table 4). The result indicated that weed infestation was comparatively lower in these treatments and their pod yield was high. The higher weed control efficiency under these treatments was reflected through to lower dry weight of weeds. It has been reported that the interaction of bentazon and other compasethoxydim is one of the most notable examples of reduced graminicide efficacy caused by herbicide that controls dicotyledonous plants and sedges (Rhodes and Coble, 1984a 1984b; Wanamarta and Penner, 1989; Wanamarta et al., 1989).

Yadav et al. (1986) reported that season-long weed competition depleted 162.8 kg N, 21.7 kg P_2O_5 and 141.8 kg K_2O per ha; effective weed control therefore negates weed nutrient removal and enhances its uptake by groundnut. Nimje (1992) reported high N removal in weedy check entries in the range 19.36 to 21.68 kg N/ha; whilst hand weeded plots lost only 4.18 to 7.12 kg N/ha).

Table 4: Percent weed control efficiency of treatments in 2011and 2012.

TREATMENTS	% WCE, 2011	% WCE, 2012	% Mean WCE
Pendimenthalin+HW@4WAP	77.2	92.6	84.9
Haloxyfop @4WAP + 1HW	69.5	87.7	78.6
Propaquizafop @4WAP +1HW	76.3	87.2	81.8
Bentazon @4WAP + 1HW	66.9	88.7	77.8
Pendimenthalin + Haloxyfop 4WAP	34.9	57.5	46.2

Pendimenthalin + propaquizafop @4WAP	42.2	94.8	68.5
Pendi menthalin+ Bentazon @4WAP	48.5	74.6	61.6
Pendimenthaline Only @4WAP	55.1	35.4	45.3
Haloxyfop @4WAP	38.2	13.6	25.9
Propaquizafop 4WAP	44.8	21.8	33.3
Bentazon @4WAP	27.3	37.4	32.4
Weedy Check	0	0	0
Weeding @ 3&6WAP	68.9	91.8	80.4

Correlation

Table 5: Correlation coefficient(r) between pod yield and other parameters.

Parameter	Canopy spread	Plant height	Nodulation	Weed biomass	Pods/plant	Haulm weight	Pod yield
Canopy spread	1.000						
Plant height	0.468*	1.000					
Nodulation	0.028	0.060	1.000				
Weed biomass	-0.205	0.279	0.023	1.000			
Pods/plant	0.402*	0.142	0.063	-0.518**	1.000		
Haulm weight	0.239	-0.002	-0.004	-0.569**	0.571**	1.000	
Pod yield	0.511**	0.445*	0.207	-0.271	0.686**	0.513**	1.000

**Significant at p <0.001 *Significant at p<0.05

CONCLUSION

Two years of field studies was carried out to determine effect of some pre- and post-emergence herbicides for controlling weeds in groundnuts in the northern savannah zone of Ghana. Percent mean weed index, which determines the reduction in crop yield due to the presence of weeds, and which was used to judge the weed control effectiveness of treatments, was least with the application of: pendimenthalin at 0.15kg a.i/ha plus one hand weeding at 4WAP, haloxyfop at 0.03kg a.i/ha plus one hand weeding 7WAP, propaquizafop at 0.02kg a.i/ha at 4WAP plus one hand weeding at 7WAP and also bentazon at 0.14kg a.i/ha at 4WAP plus one hand weeding at 7WAP. In a similar vein the same treatments gave comparable weed control efficiencies of 78 to 85% as the accepted farmer control practice of twice weeding at 3 and 6 weeks after planting. Combination of pre- and post-emergence herbicides as a weed control package in groundnuts does not appear advantageous over other treatments. Season-long weed infestation reduced pod yield by 36% in 2011 and 76% in 2012. Summed dominance ratio of weed species amplified prevalence of broadleaves of *Ageratum conyzoides* (L), *Corchorus olitorius* (Linn) and *Ludwigia abyssinica* (A. Rich). Season-long unweeded weed control gave pod yield loss of 43 to 69%.

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