Growth and Yield Response of Soybean under Different Weeding Regimes

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ABSTRACT— ***Studies were conducted during the 2011 cropping season at experimental field of the Faculty of Agriculture, University for Development studies in the Guinea Savanna agro ecological zone. The objectives of the study were to determine the effect of different weeding regimes on the growth and yield of soybean and also assess the economic feasibility of the weeding regimes. The experimental design was Randomized Complete Block Design (RCBD) with four replications. The treatments were five different weeding regimes which were no weeding, weeding at 3, 6 WAP, weeding at 3, 6, 9 WAP, weeding at 3, 6, 9, 12 WAP and weed free. Data collected included plant height, leaf area, stem girth, pod number and grain yield. Significant differences were observed among treatments on plant height, number of leaves per plant, stem girth, leaf area, number of days to 50% flowering, number of pods per plant and grain yield (kg/ha). The mean predominant weed floras at the experimental field were broad leaves (58.62%), sedges (26.93%) and grasses (14.44%). Weeding regime at 3, 6, 9, 12 WAP produced the highest grain yield of 1411 kg/ha. The economic analysis of the treatments also shows that farmers will be better off by adopting 3, 6, 9, 12 weeks after planting weeding regimes. Weeding at 3, 6, 9, 12 WAP is therefore recommended for high soybean yield and income.***

Keywords— Soybean, weeding regime, yield, partial budget and Net benefit

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1. INTRODUCTION

Soybean (*Glycine max* (L) Merrill) is a member of the Leguminosae family and subfamily Papilinoideae. Soybean is an annual herbaceous legume that originated from North-eastern China and has been cultivated for the past three millennia (Simmond *et al.,* 1999). The crop is now cultivated throughout the world with the largest production in the United State of America, Brazil, China and Argentina (Javaheri and Baudoin, 2001). Soybean is the most important grain legume crop in the world in terms of total production and international trade (Simmond *et al.*, 1999). It is an oil crop rich in protein and used to fortify various foods in order to improve their nutritional quality (IITA, 1990). Soybean contains about 20% oil on dry matter basis with 30-50% of protein (Kwarteng and Towler, 1994). It has been estimated that 1.6 million metric tonnes of soybean are needed annually to satisfy domestic and industrial need (Mamman, 1990). In Ghana, the Northern region records the highest soybean production with an average yield of 2.5 ton/ha (Awuku, 1991). According to Odeleye *et al.,* (2007) there is a wide margin between what is needed and what is currently produced. Soybean performance during cultivation is a function of crop genetic composition and environmental factors; hence both abiotic and biotic factors must be optimum. Pests have devastating effect on agronomics and economics of soybean production, affecting yield and quality of grain and seeds of which weeds are of no exception (Conner *et al.,* 2004). One of the most important aspects of soybean production is weed management. Uncontrolled weeds could reduce yield of soybean by up to 5% depending on the density and variety (Nathanael *et al*., 2013). In economic terms, the average yield loss of 5 percent predicted in that study translates into a loss of $26.72 per acre at 2011 crop prices. Uncontrolled weeds not only reduce soybean yields through their competition for light, nutrients, and moisture, but they can also severely reduce harvest efficiency (Norris, R. F. 1999). The most effective weed management programs in soybeans uses a combination of cultural, mechanical, and chemical control strategies (Grichar *et al*., 2004). Cultural practices include such factors as planting date, planting rate, and row spacing (Holshouser *et al*., 2002). Cultural practices improve weed control by enhancing the competitive ability of the crop. A multitude of herbicides are labeled for use in soybeans and can be applied pre plant incorporated, pre-emergence, post emergence, and post-directed (Kells *et al*., 2004). Weeds can be most effectively managed in soybeans with a well-planned program that involves a thorough analysis of the field situation. Before implementing a weed management plan for soybeans, several factors need to be considered including weed species, rotational crops and cost (Pike, D. R. 1999). If a weed management program in soybeans is going to be successful and economical, a thorough understanding of the competitive effects of weeds is important (Pike, D. R. 1999).

In regards to this area, two things must be considered; when do the weeds need to be controlled in order to prevent significant yield losses and how much yield loss are they actually causing. The most effective weed control system depends on the kinds of weeds in the field, soil characteristics, tillage practices, crop rotation, and soybean row width (Pike, D. R. 1999). Contrary views exist as to the right time for effective weed control. Hand weeding is the predominant weed control practice on smallholder farms (Vissoh *et al*., 2004). Keeping the crop free of weeds for the first third of its life cycle usually assures near maximum productivity (Doll, 2003). According to Orr *et al*. (2002) two properly spaced hand weeding within eight weeks of planting of maize (at three weeks and six weeks) give yields comparable to keeping the crop weed-free for the first eight weeks after planting. Consequently, farmers usually weed their farms at different times and different intervals. The main objective of this study was to evaluate the performance of soybean (Quarshie variety) under various weeding regimes.

2. MATERIALS AND METHODS

2.1 Experimental site description

A field trial was conducted on the experimental fields of the University for Development Studies, Nyankpala (09°24’15.9’’N; 01°00’12.1’’W) in the Guinea Savannah ecological zone (SARI, 2008). The climate in the study area is warm and semi-arid with a unimodal rainfall pattern. The area has an average annual rainfall of 1034.4mm with wide distribution from April to November (SARI, 2008). Temperature distribution is uniform with mean monthly minimum and maximum of 23.4°C and 34.5°C respectively (SARI, 2004). The relative humidity is characterized by a greater increase during the raining season to a minimum monthly value of 53% during dry season (SARI, 2004). The soil is characterized by moderately drained sandy-loam, brown, very shallow and free from concretions with a hard pan underneath.

2.2 Experimental design and treatments

The experiment was laid in a randomized complete block design (RCBD) with five treatment and four replicates. There were twenty experimental plots each measuring 3.0m by 3.0m with inter- block and inter-plot distance of 1.5m and 1.0m respectively. The total land size for this experiment was 19m by 16.5m. The treatments consist of no weeding, weeding at 3, 6 WAP, weeding at 3, 6, 9 WAP, weeding at 3, 6, 9, 12 WAP and weed free. The test crop (Glycine max cv Quarshie) was obtained from the Savanna Agricultural Research Institute (SARI), Nyankpala, Tamale.

2.3 Management Practices

The experimental field was ploughed and harrowed using a tractor and ridges were constructed manually. Weeding operations were carried out using the hand-hoe. The experiment was conducted under rainfed conditions. Mineral fertilizer (Triple Superphosphate) was applied uniformly at the rate of 30 kg P/ha at two weeks after sowing by burying the fertilizer material in trenches dug at 5 cm away from the hill. The plants did not suffer from any major pest and disease attack during their growth hence no spraying was done.

2.4 Data Collected

Data was collected on growth parameters at every two weeks interval. Data were measured on the following crop variables; crop establishment, plant height, leaf area, canopy spread, number of pods, pod weight per plant and total grain yield.

2.5 Weeds identification and scoring

A 1m x 1m quadrant was randomly thrown two times on each plot and the number of weed species found within the quadrant and their densities were recorded. A score of 0-4 was given depending on the number of times particular weed species appears in the quadrant. A score of 0 indicates that a particular weed species did not occur in the quadrant. An occurrence of one (1) weed specie was given a score of 1. A weed occurrence between 2 and 5 were given a score of 2. A score of 3 was given to a weed occurrence between 6 and 19 while a score of 4 indicates that a particular weed specie occurs 20 times or more. The weed identification and scoring was taken at 3, 6, 9 and 12 weeks after planting (WAP) according to the treatments. The sum dominance ratio (SDR) of the weed species were calculated from the equation $\frac{1}{2}(\mathbf{f}/\sum\mathbf{f} + \mathbf{d}/\sum\mathbf{d}) \times 100$ where **f** and **d** are the frequencies and densities, also $\sum$**f** and $\sum$**d** are summation of frequencies and densities respectively.

2.6 Economic analysis

Economic analysis was carried out using the prevailing market prices for inputs at planting and for outputs at the time the crop was harvested. All costs and benefits were calculated on hectare basis in Ghana cedi (Gh ¢). The following concepts used in the partial budget analysis are defined as Mean grain yield is the average yield (t/ha) of each treatment. The average yield was adjusted downwards by 10%. The adjusted yields represent the potential yield from the farmer's field using the same treatments. The gross field benefit was calculated by multiplying the field price by the adjusted yield. The net benefits were calculated by subtracting the total costs that vary from the gross field benefits for each treatment.

2.7 Data analysis

All data collected were entered into Microsoft excel and subjected to Analysis of Variance (ANOVA) using GENSTAT (2008 Edition) and treatment means were compared using the least significance difference (LSD) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Plant height (cm)

Plant height differed significantly among weeding regimes (Table 1). Weeding regime at 3, 6, 9, 12 WAP produced the highest plant height. The significantly ($P<0.05$) higher plants observed with 3, 6,9,12 WAP plots and weed free plots could be as a result of less weed competition with the plant for nutrients, light, water and space as reported by Odeleye *et al*. (2007) and Reddy and Whiting (2000). The results also agrees with findings by Ayeni and Oyenka (1992), who reported that the longer the duration of weed interference the stronger the depressive effect on soybean plant height. No weeding regimes recorded the least plant height which agreed to the findings of Barretine and Oliver (1997) who observed lower plant height on no weeding plots. This could be attributed to the stress caused by weeds and their competitive ability for nutrients and other growth factors such as light, moisture and space. Weeds have comparative power to suppress the height of soybean plant.

3.2 Leaf area (cm^2)

There was a significant difference ($P<0.05$) among treatments in leaf area. Soybean plants weeded on 3, 6, 9, 12 WAP recorded the highest leaf area per plant (Table 1). Low weed density might lessen the competition of weeds for nutrients for the enhancement of leaf production with larger areas as reported by Harder *et al*. (2007). Plants on the no weeding plots recorded the minimum leaf area, due to high weed density interference. Similar effect of weed- crop competition has also been reported by Dzormeku *et al*. (2009) and Hance and Holly (1998).

3.3 Number of leaves

Highest significant ($P<0.05$) differences were observed among number of leaves. Plants of the plots weeded at 3, 6, 9, 12 WAP also produced similar number of leaves as the weed free plots (Table 1). This suggests their effectiveness in reducing niche available to weeds. The result is consistent with the findings of Labrada *et al*. (1994) who reported that the tendency of weeding decreased niche available to weeds. On the other hand, the soybean plants of the no weeding plots had the least number of leaves per plant which might be attributed to the competitive ability of weeds in terms of nutrients and other growth factors. This is similar to the findings by Halford *et al*. (2001) who observed the suppressive ability of weeds on soybean vegetative characters such as the number of leaves produced by each plant.

3.4 Stem girth (cm)

The results show significant differences ($P<0.05$) among treatments. The significantly ($P<0.05$) higher stem recorded was due to less or minimum pressure from weeds. The results supports the findings of Dzormeku *et al*. (2009) who reported that weed control lessened or decreased weeds competition for nutrients and enhanced the availability of nutrient which promotes the enlargement or growth of the stem girth as also reported by Gupta (1998). Plants on no weeding plots recorded the lowest stem girth which is attributed to the competition with high weed infestation. This confirms the study conducted by Haygood *et al*. (1998) that soybean field with high weed density increased the competition for nutrients, light, water and space which discouraged the growth and development of the vegetative parts such as the stem girth.

Table 1: Effect of different weeding regimes on growth parameters of soybean

Treatment	Plant height (cm)	Leaf area (cm^2)	Number of leaves	Stem girth (cm)
3,6 WAP	29.91	27.86	94.13	2.04
3,6,9 WAP	32.27	28.57	86.36	1.96
3,6,9,12 WAP	33.27	31.95	96.95	2.12
No Weeding	28.73	22.88	57.07	1.74
Weed free	33.07	31.74	100.48	2.14
S. e. d	1.71	2.45	8.48	0.11
CV%	7.0	12.16	12.0	7.3

3.5 Days to 50% Flowering

The results shows that weed free plots recorded the lowest number of days to 50% flowering (Fig. 1). Flowering earlier could be attributed to less weed competition for nutrients leading to early growth and development. No weeding plots recorded the highest number of days to 50% flowering. The observations supports the study conducted by Tijani and Akinnifesi (1998) and Odeleye *et al*. (2007) that flowering of soybean always delayed significantly on fields with high weed density due to high weed interference on the growth and development of the soybean.

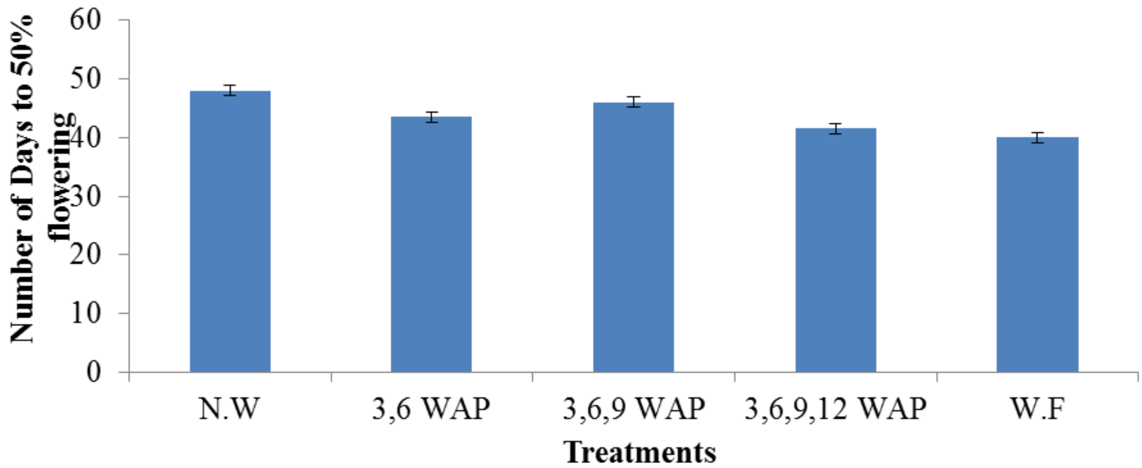

Fig. 1: Effect of different weeding regimes on number of days to 50% flowering. Bars represent SEM

3.6 Number of pods

The highest number of pods per plant was obtained from the treatment 3, 6,9,12 WAP (Table 2). This could be attributed to frequent and adequate weeding which conformed to findings of Dugie *et al*. (2009) who reported that weeding suppress or minimized the growth, development and competitive capacity of weeds thereby enhancing optimum pod formation. Nangju (1980) also reported that weeding of soybean field ensures availability of nutrients such as phosphorus, potassium, nitrogen and other micro-nutrients which promotes rapid and more pod formation. The soybean plants on the no weeding plots recorded the least number of pods due to high competition by weeds for nutrients stated above as well as moisture, light, space and other growth factors over the plant, which lead to less pod formation and development. This was also in line with the study conducted by Lavabre (1991).

3.7 1000 seed weight (g)

1000 seed weight was significantly (P<0.05) affected by 3, 6,9,12 WAP weeding regimes compared with the other treatments (Table 2). The results obtained from the various treatments were in support of the study conducted by Halford *et al*. (2001) and Haygood *et al*. (1998), who reported of decreased 100 seed or grain weight with high weed density.

3.8 Total grain yield (kg/ha)

The results of the total grain yield (Table 2) indicates that yield from 3,6,9,12 WAP weeding regimes produced the significantly highest grain yield followed by plants of the plots weeded at 3,6,9 WAP. According to Pedersen and Lauer (2004), weed control enhanced adequate flowering through the length and quality of light needed by the soybean plant which had great impact on its grain yield. Moreover, the availability of adequate soil moisture, nutrients and other growth factors due to less weed competition also contributed to optimum soybean yield which is similar to the study conducted by Reddy (2002). The soybean plants on the no weeding plots produced the least grain yield due to high density, growth and competition of weeds. Weeds such as *Senna obtusifolia, Paspalum srobiculatum* and *Rottboellia cochinchinensis* grew tall which tend to shade most of the soybean plants thereby reducing the optimum amount of sunlight needed for photosynthesis as reported by Nice *et al*. (2001). Similarly, weeds such as *Cyperus rotundus*, *Ludwingia decurrens*, *Acanthospernum hispidum* are deep rooted which tend to compete with the soybean plant for nutrients, water and other growth factors available in the soil. According to Nathanael *et al*. (2013) weed is a major pest which reduced yield of soybean by 5% depending on the density and variety.

Table 2: Effect of different weeding regimes on number of pods, 1000 grain weight and total grain weight

Treatment	Number of pods	1000 seed weight (g)	Total yield (kg/ha)
3, 6 WAP	73.3	96.0	1122
3, 6, 9 WAP	47.9	98.0	1333
3, 6, 9, 12 WAP	76.1	108.0	1411
No weeding	24.1	87.0	372
Weed free	70.7	96.0	1317
S. e. d	3.97	6.40	42.9
CV (%)	9.6	9.4	5.5

3.9 Weeds identification and scoring

Fifteen weeds were identified during the study. Broad leaves species were observed to be dominant on the field, followed by sedges and grasses (Table 3). The occurrence of the weed species were in a range of 58.62% for broad leaves, 26.93% for sedges and 14.44% for grasses. The broad leaves identified were *Ageratum conyzoides, Phyllanthus amarus, Commelina bengalensis*, *Senna obtusifolia*, *Acanthospernum hispidum*, *Ludwingia decurrens*, *Eurphorbia hirta, Mitracarpus villosus* and *Croton lobatus.* The grasses were *Paspalum scrobiculatum, Digitaria horizontalis, Brachiaria lata*, and *Rottboellia cochinchinensis.* The sedges were *also Cyperus esculentus* and *Cyperus rotundus.* The presence of different weed species or flora on the experimental field could be due to continuous disturbance or cropping on the field and also favourable edaphic conditions since soybean is known for nitrogen fixation. The result showed that broadleaves dominated on both no weeding and hand weeding plots, this could be attributed to the fertile nature of the site as reported by Chikoye *et al*. (2004) who reported that broadleaf weeds could increase as soil fertility also increased.

Table 3: Weed species at the experimental site during the 2011 cropping season

WEED SPECIES	SDR (%)				
	3 WAP	6 WAP	9 WAP	12 WAP	MEAN SDR
Broad leaves	**55.03**	**64.60**	**60.01**	**54.84**	**58.62**
Ageratum conyzoides L	14.08	16.50	15.02	13.96	14.89
Phyllanthus amarus (Shuum and Thann)	3.34	4.70	4.06	3.52	3.91
Commelina bengalensis L	4.72	5.21	5.99	5.02	5.24
Senna obtusifolia L	4.06	6.14	3.67	5.70	4.89
Acanthospernum hispidum (DC)	2.82	3.60	2.43	2.76	2.90
Ludwingia decurrens	12.60	13.01	15.50	13.85	13.74
Eurphorbia hirta L	8.10	7.30	5.84	4.81	6.51
Mitracarpus villosus (SW) DC	4.22	5.90	4.88	5.22	5.06
Croton lobatus	1.09	2.24	2.62	0.00	1.49
Grasses	**15.80**	**12.62**	**13.33**	**16.01**	**14.44**
Paspalum scrobiculatum L	4.08	4.51	4.72	5.03	4.59
Digitaria horizontalis (Wild)	3.88	2.01	3.00	3.32	3.05
Brachiaria lata (Shuum)	5.08	3.02	2.32	4.05	3.62
Rottboellia cochinchinensis (Lour)	2.76	3.08	3.29	3.61	3.19
Sedges	**29.17**	**22.78**	**26.66**	**29.11**	**26.93**
Cyperus esculentus L	15.34	12.96	16.44	17.09	15.46
Cyperus rotundus L	13.83	9.82	10.22	12.02	11.47
	100	**100**	**100**	**100**	**100**

3.10 Economic Analysis

The results in this study indicated that the total grain yield (discounted at 10%) ranged from 334.8 kg/ha in the no weed plot to 1269.9 kg/ha (Table 4). There were significant difference (P<0.05) between 3, 6, 9, and 12 WAP and no weeding plot. The yield value in (Ghana cedis) ranged from GH ¢ 669.6 (USD 223.2) in the no weed plot to GH ¢ 2539.8 (USD 846.6) in the 3, 6, 9 and 12 WAP weeding regimes. The cost that vary ranged from GH ¢ 0 (USD 0) in the no weed plot to GH ¢ 300 (USD 100) in the 3, 6, 9 and 12 WAP weeding regimes. The net profit value in (Ghana cedis) ranged from GH ¢ 669.6 (USD 223.2) in the no weed plot to GH ¢ 2299.8 (USD 766.6) in the 3, 6, 9 and 12 WAP weeding regimes. The profitability analysis of soybean production was discounted at 10% for all the treatments. Generally, all the treatments had higher benefit over no weed control. The low net benefit recorded in the control may be due to low yield as a result of high weed competition leading to depletion of nutrients for the crop growth and development (Nathanael *et al*., 2013).

Table 4: Partial budget for five different weeding regimes of soybean seeds

Item	Treatment				
	Weeding regimes				
	3, 6 WAP	Weed free	3, 6, 9 WAP	3, 6, 9, 12 WAP	No weeding
Average yield (kg/ha)	1122	1317	1333	1411	372
Adjusted yield (kg/ha)[1]	1009.8	1185.3	1199.7	1269.9	334.8
Gross field benefit (*GH ¢/ha*)[2]	2019.6	2370.6	2399.7	2539.8	669.6
Cost of weeding (*GH ¢*/ha)	120	300	180	240	0
Cost of seeds (*GH ¢/ha*)	0	0	0	0	0
Total cost that vary (*GH ¢/ha*)	120	300	180	240	0
Net benefit (*GH ¢/ha*)	1899.6	2070.6	2219.7	2299.8	669.6

[1]Average yield adjusted 10% downwards; Farm gate price of soybean as at December 2011= GH ¢ 2.0 per kg; Price of weeding 1 hectare as at December, 2011= GH ¢ 60.00

4. CONCLUSION

Application of different weeding regimes had a significant effect on plant height, number of leaves per plant, stem width, leaf area per plant, number of pods per plant, 1000 seed weight and grain yield per plot. The results obtained revealed that 3, 6, 9 and 12 WAP weeding regimes recorded the highest grain yield compared to the other treatments. The economic assessment of the treatments have also showed that application of 3, 6, 9, and 12 WAP weeding regimes was more profitable than all the other treatments. Based on the findings of this experiment, it is recommended that the application of 3, 6, 9, and 12 WAP weeding regimes could maximize grain yield and farm income.

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