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Growth and Yield of Soybean (*Glycine max* (L.) Merr) as Affected by Plant Population and Herbicide Weed Control Methods in Delta State, Nigeria

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ABSTRACT

Field experiments were conducted between July and November, 2015 and 2016 rainy seasons to determine the effect of plant population and herbicides weed control methods on growth and yield of soybean in Mosogar (Altitude 22 metrers above sea level, Latitude $5^0 55^1$N , Longitude $5^0 46^1$ E) in the wet rain-forest zone of Delta State. The experiment included five weed control treatments (control, hoe weeding at 3 and 6 Weeks after planting (WAP), pendimethalin (1.16kg ai/ha) at one day after planting (1DAP), fusilade forte (0.23kg ai/ha) at 3 weeks after planting (WAP), and pendimethalin (1.16kg ai/ha) at 1DAP followed by fusilade forte (0.23kg ai/ha) at 3 WAP and three plant populations 500,000, 333,333 and 266,666, plants/ha. This was combined in a 5 by 3 factorial experiment laid out in Randomized Complete Block Designed (RCBD) in three replicates. The results obtained showed that the herbicides and hoe weeding methods significantly ($P<0.05$) enhanced growth and yield attributes when compared with the control. Plant population at 500,000 plants /ha and pendimethalin followed by fusilade forte (1.16 + 0.23kg ai/ha) herbicide weed control method were found to be superior in various growth and yield components and thus recommended for soybean farmers in the area.

Keywords: plant population, weed control methods, growth and yield of soybean

INTRODUCTION

Soybean (*Glycine max*) is prominent for its high protein as well as oil content. The protein and oil content account for about 60% of dry soybean weight: protein 40% and oil 20% and this is 85 % unsaturated and cholesterol-free (Sodangi *et al*., 2006; Dugje *et al*., 2009). In Africa, countries known for soybean production are Zambia, Nigeria, Zimbabwe, Rwanda, Uganda and Ethiopia. The average yield of soybean in Nigeria is 1000kg/ha while the world average is reported to be 1800kg/ha. However, with improved management practices yield of up to 25000kg/ha is achievable (Onwueme and Sinha, 1991; Imoloame, 2014).

Soybean is an important grain legume that contributes to improving soil fertility and reduces *Striga hermonthica* infestation on farmers field (Frankie *et al*., 2004 and Dugje *et al*., 2009) It fixes atmospheric nitrogen (45- 60 kg/ha) through leaf fall (Kanase *et al*.,2006). Soybean uses are enormous and range from soil improvement to both animal and human consumption. The uses for soymilk, yoghurt, soybean oil, bread fortifier are well known industrial utilization. The demand for soybean and its by-products, especially soymilk, soy cakes and soy fortified bread has been increasing steadily over the years. Yield losses in soybean have been reported to be attributable to weed-crop competition and low soil fertility (Sodangi *et al*., 2011). Yield losses in soybean due to

weed competition were reported to be between 40-90% depending on climatic factors, land preparation methods and intensity of weed infestation (Daugavish *et al*., 2003, Sodangi *et al*., 2013, Hassan, 2013 and Imoloame, 2014) especially where the land has been extensively used.

Weed management methods and plant population manipulation influences yield of soybean as shown by the work of various researchers. Dally *et al*. (2004) studied the effect of time of application of glyphosate and row spacing on weed growth on soybean. They found out that soybean planted in narrow rows (of 19cm and 38cm) had less biomass of weed emerging after glyphosate application than 76cm row. Olofintoye (1998) reported that weeds were more effectively reduced in narrow row than in wider row. Hassan (2013) investigated several herbicides on weed control in soybean along with hand hoeing twice at 15 and 25days after planting. The results obtained showed that the favourite weed control treatments were hand hoeing twice followed by pendimethalin, dinitriamine and linuron used at manufacturer's recommended rates. Studies by Renner and Mickelson (1997) showed that soybean suppressed late emerging weeds and any weed that survived a post-herbicide. The need to increase output and meet the ever increasing demand for soybean and its by-products necessitate weed management strategies that removes the drudgery associated with traditional methods. One of such strategies is the use of herbicides. This study therefore aimed at determining the effect of plant population and herbicides weed control methods on the growth and yield of soybean.

MATERIALS AND METHODS

Two field experiments were conducted during the rainy seasons of 2015 and 2016 (July to November) at the College of Physical Education farm, Mosogar, Delta State. Mosogar is located between Latitude $5^0\ 55^1$ n and Longitude $5^0\ 46^1$ E and is characterized by a long wet season lasting from March to October that alternates with a short dry season that last from November to February. Annual rainfall is high usually up to 2500 mm per annum. The rainfall period is double-peak, the two period peak of rainfall are June/July and September; separated by a relatively dry period in August (Aweto, 2002). Annual temperature average is about 27^0 with no marked seasonal departure from the average temperature as the annual range of temperature is quite small, rarely exceeding 3^0 (Aweto,2002).

The soil texture of experimental site is sandy loam. The land was manually cleared and the trash packed within the first week of June in the two seasons to allow the first flush of weeds to grow. Two weeks before the planting of seeds the first flush of weed was killed with glyphosate (force-up) at 4l/ha (Dugje *et al*., 2009).

The experiment consisted of three plant populations and five weed control methods. The three plant populations are 500,000, 333,333 And 266,666 plants/ha while the weed control methods are; control, hoe weeding (3 and 6WAP), pre emergence application of pendimethalin at 1.16kg ai/ha (1DAP), post emergence application of fusilade forte at 0.23 kg ai/ha (3WAP) and pendimethalin (1DAP) followed by fusilade forte (3WAP). The three plant population and five weed control treatments were combined in a 5 by 3 factorial experiment in Randomized Complete Block Designed (RCBD) in three replicates. The plot size was 3m x 2m with an alley way of 1m among plots and 1m between replicates. The experimental area was 46m x 13m ($598m^2$) or 0.06ha. Seeds of soybean (variety TGx 1740-1F) were planted on 14/ 07/2015 and 14/07/2016 at the specified plant populations (500,000 ; 333,333 and 266,666 plants/ha) corresponding to row spacing of 40, 60, and 75cm respectively.

The herbicides pendimethalin and fusilade forte were applied one day after planting and 3WAP respectively. The herbicides were applied with a hand operated 16 litres knapsack sprayer (CP 16) with the flat fan nozzle (swathe width 0.5 m) calibrated to deliver 220l/ha. Hoe weeding treatment was carried out at 3 WAP and at 6 WAP with the aid of hoe. Soybean seeds sown at 6 seeds per hole were thinned to two seedlings per stands at 2 WAP and a basal application of 20 kg N/ha, 40 kg $P_2\ 0_5$/ha and 20 kg K_2O/ha in 2015 and 2016 cropping seasons was carried out.

Parameters measured

The parameters measured included plant height taken at 4WAP and thereafter at 2 weeks interval, number of leaves per plant, leaf area by formula, A= 0.411 + 2.008 LW (length x width x factor). Where A= trifoliate leaf area, L and W= maximum length and width of terminal leaflet of trifoliate leaf respectively while 0.411 and 2.0 08 were constants (Weisma and Bailey, 1975). Others are leaf area index (LAI), stem diameter number of branches and days to 50% flowering. Yield and yield components includes number of pods per plant, pod dry weight per plant, 100 seed weight, shelling %, total grain and stover yield.

RESULTS AND DISCUSSION

Vegetative and flowering traits

Plant height, number of leaf, leaf area, LAI, and number of branches were significantly ($P<0.05$) affected by the hoe and herbicides methods of weed control and plant population (Tables 1,2,3,4 and 5). Control plots recorded the lowest values of these parameters while the highest value among the herbicides weed control methods was recorded in pendimethalin + fusilade forte. Plant population treatments showed that high plant population (500,000 plants/ha) produced the highest for the vegetative traits. Interaction between plant population and the weed control methods in the two seasons were also significant. The consistent superiority of the herbicides and hoe weeding methods over the control plots in the growth parameters can be attributed to effective weed control in these plots resulting from competition for water, nutrients and light between the crop and the weeds. On the other hand, the height of soybean in the high population (500,000 plants/ha) over the medium (333,333plants/ha) and low (266,666 plants/ha) plant population treatments was due to effective weed control. The expected weed competition in control plots led to reduction in the height, number of leaf, leaf area, LAI, and number of branches. The herbicides and hoe weeding treatments offered a better environment for the enhancement in growth parameters in the two seasons. When high population combined with effective weed control growth is maintained. The enhancement in growth attributes which resulted from herbicides control methods is supported by the findings of Smita *et al*. (2014) and Peer *et al*. (2014). In this study, leaf area, and LAI increased with increasing plant population. This is in agreement with the work of Olofintoye (1998) and Kamara *et al*.(2013) who reported higher leaf area and LAI at higher plant populations.

Yield and yield attributes

Table 6 and 7 presents yield and yield attributes of soybean as affected by herbicides and plant populations. Among the herbicides weed control methods, pendimethalin + fusilade forte plots had highest number of pods per plant, pod weight per plant, seed weight per plant, 100 seed weight, total grain and stover yield. This was followed by pendimethalin alone plots in both seasons. In the two seasons high plant population plots (500,000 plants/ha) produced highest value for the yield and yield attributes and it was significantly different from the medium (333,333 plants/ha) and low plant population (266,666 plants/ha) treatments. Herbicides and plant population interactions were also significant. The findings of Olofintoye (1998), Sodangi *et al*. (2006), Kamara *et al*. (2013) and Hassan (2015) indicated that soybean yields can be increased by use of higher plant population. In addition, increasing plant population do not provide enough room for the weeds to compete with the soybean crop for space, water and light. This results in weed suppression at high plant population because of rapid canopy closure.

CONCLUSION

This study was designed to determine the effect of plant population and herbicides weed control methods on growth characteristics and yield of soybean. The study indicated that plant population and herbicides weed control methods enhanced significantly growth and yield components of soybean in the study area. Interaction between herbicides weed control methods and plant population was also found to be significant in both seasons of the experiments. Pendimethalin +

fusilade forte (1.16kg ai/ha +0.23 kg ai/ha) was found to be superior in both growth and yield attributes in the study area.

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Table 1: Effect of weed control and cropping densities on plant height (cm) in soybean in 2015 and 2016 cropping seasons (Mosogar).

Treatments	Week After Planting (WAP) 2015					Week After Planting (WAP) 2016				
	4	6	8	10	12	4	6	8	10	12
Weed control										
Unweeded	12.61b	18.50a	28.9a	34.57a	37.64a	16.56a	27.49a	37.78a	45.67a	45.79a
Hoe weeding (3&WAP)	17.97b	26.82c	46.59c	58.28c	60.04c	17.13a	31.29b	50.39d	63.96b	65.62c
Pendimethalin (1.16 kg a.i./ha)	16.77a	25.13c	42.90b	51.05b	51.89b	16.73a	29.79ab	44.53c	56.87b	57.08b
Fusilade forte (0.23 kg a.i./ha)	13.27b	20.96b	30.91a	35.97a	37.81a	16.68a	29.32a	41.63b	56.00b	56.28b
Pm + Ff (1.16 + 0.23kg a.i./ha)	17..95a	26.00d	43.60b	55.39bc	57.99c	17.06a	30.56b	47.30c	58.14b	58.28b
LSD (0.05)	1.79	0.76	2.63	4.59	5.06	1.35	2.30	2.85	4.89	6.03
Density										
500,000	15.91a	25.11b	40.45b	49.90b	51.18a	17.41b	32.21b	51.32c	65.09c	64.91b
333,333	15.69a	22.93a	37.60a	46.54a	48.18a	17.06a	30.50b	43.96b	53.77b	54.30a
266,666	15.55a	22.40a	37.70a	44.71a	47.86a	16.03a	26.35a	37.70a	49.53	50.46a
LSD (0.05)	1.39^{ns}	0.59	2.04	3.55	3.92	1.05	1.78	2.20	3.79	4.67
Interaction										
WXD	3.10*	1.31*	4.56*	7.95*	8.76*	2.35*	3.98*	4.93*	8.47*	10.45*

Table 2: Effect of weed control and cropping densities on number of leaves (nos./plant) in soybean in 2015 and 2016 cropping seasons (Mosogar).

	Week After Planting (WAP) 2015					Week After Planting (WAP) 2016				
Treatments	**4**	**6**	**8**	**10**	**12**	**4**	**6**	**8**	**10**	**12**
Weed control										
Unweeded	4.58a	7.10a	10.48a	13.65a	13.98a	5.38a	7.78a	9.80a	14.63a	15.06a
Hoe weeding (3&6WAP)	5.62b	8.23b	11.73a	15.54a	16.15a	6.04c	8.93b	13.26c	18.54b	21.16c
Pendimethalin (1.16 kg a.i./ha)	5.49b	8.03b	11.36a	14..18a	15.86a	5.79b	8.34ab	11.78b	16.11a	17.55a b
Fusilade forte (0.23kg a.i./ha)	5.26b	7.36a	10.63a	13.94a	14.96a	5.72b	8.24ab	10.96b	15.19a	17.52a b
Pm +Ff (1.16 +0.23kg a.i./ha)	5.53b	8.04b	11.63a	14.79a	15.98a	5.81b	8.87b	12.99c	17.23a	19.12b
LSD (0.05)	0.42	0.52	1.24	2.75	2.65	0.26	0.88	1.00	2.97	3.62
Density										
500,000	5.19a	7.53a	11.07a	13.53a	14.45a	5.81a	8.02a	10.77a	15.83a	17.40a
333,333	5.27a	7.77a	10.69a	14.70a	15.68a	5.62a	8.63a	11.93b	15.44a	17.09a
266,666	5.43a	7.97a	11.73a	15.03a	16.03a	5.81a	8.65a	12.57b	17.76a	19.75a
LSD (0.05)	0.33	0.40	0.96	2.13	2.05	0.20	0.68	0.73	2.30	2.80
Interaction										
WXD	0.73*	0.90*	2.15*	4.76*	4.59*	0.46*	1.52*	1.73*	5.14*	6.27*

Table 3: Effect of weed control and cropping densities on leaf area per plant (cm^2) in soybean in 2015 and 2016 cropping seasons (Mosogar).

	Week After Planting (WAP) 2015					Week After Planting (WAP) 2016				
Treatments	**4**	**6**	**8**	**10**	**12**	**4**	**6**	**8**	**10**	**12**
Weed control										
Unweeded	199.1b	425.6b	623.2a	670.5a	729.4a	230.2a	535.4a	796.1a	1043.9a	998.2a
Hoe weeding (3&6WAP)	203.6b	476.1b	892.4c	1003.4b	917.3a	278.9a	777.6b	1158.7c	1564.5b	1608.8b
Pendimethalin (1.16 kga.i./ha)	65.9a	269.9a	851.0c	894.1a	827.3a	267.7a	720.5b	1025.2b	1385.6a	1378.2a
Fusilade forte (0.23Kga.i./ha)	202.1b	442.4b	756.7b	802.4a	737.2a	245.3a	675.9a	972.1b	1383.4a	1351.0a
Pm + Ff (1.16 + 0.23kg a.i./ha)	95.6a	304.3a	871.7c	949.1ab	894.4a	274.4a	776.0b	1069.9b	1479.3b	1530.4b
LSD (0.05)	43.5	55.7	55.4	286.9	303.6	56.6	159.1	136.9	417.5	433.2
Density										
500,000	161.7a	368.8a	898.6b	935.3a	944.2a	277.7b	768.3b	1100.4b	1382.2a	1363.9a
333.333	150.2a	399.7a	749.9a	825.6a	850.1a	221.3a	564.4a	931.0a	1175.7a	1209.4a
266,666	147.7a	382.4a	748.5a	830.8a	788.2a	278.9b	758.6b	982.1a	1556.1b	1547.4a
LSD (0.05)	33.7	43.2	42.9	222.2	235.2	43.8	123.2	106.1	323.4	355.6
Interaction										
WXD	75.3*	96.5*	95.9*	496.9*	525.8*	98.0*	275.5*	237.1*	723.2ns	750.3ns

Table 4: Effect of weed control and cropping densities on leaf area index (LAI) in soybean in 2015 and 2016 cropping seasons (Mosogar).

	Week After Planting (WAP) 2015					Week After Planting (WAP) 2016				
Treatments	**4**	**6**	**8**	**10**	**12**	**4**	**6**	**8**	**10**	**12**
Weed control										
Unweeded	0.13a	0.49a	1.16a	1.16a	1.28a	0.41a	0.96a	1.48a	1.87a	1.81a
Hoe weeding (3&6WAP)	0.38c	0.85b	1.76b	1.97b	1.78a	0.52a	1.47b	2.18c	2.90b	2.90b
Pendimethalin (1.16 kg a.i./ha)	0.36b	0.80b	1.54b	1.60ab	1.68a	0.49a	1.35b	1.88b	2.51ab	2.51ab
Fusilade forte (0.23 kg a.i./ha)	0.26b	0.54a	1.33a	1.48a	1.56a	0.44a	1.26b	1.80b	2.50ab	2.44ab
Pm0 + Ff (1.16 + 0.23 kg a.i./ha)	0.38c	0.82b	1.54b	1.90b	1.74a	0.51a	1.46b	2.02bc	2.69ab	2.80b
LSD (0.05)	0.11	0.10	0.24	0.45	0.51	0.11	0.27	0.27	0.83	0.86
Density										
500,000	0.40b	0.92c	2.14c	2.34b	2.36b	0.69b	1.92b	2.75c	3.46b	3.41b
333,333	0.25a	0.67b	1.25b	1.42a	1.42a	0.36a	0.96a	1.55b	1.96a	2.01a
266,666	0.20a	0.51a	1.00a	1.11a	1.05a	0.37a	1.01a	1.31a	2.07a	2.06a
LSD (0.05)	0.09	0.07	0.19	0.35	0.40	0.09	0.21	0.21	0.65	0.66
Interaction										
WXD	0.20*	0.17*	0. 41*	0.79*	0.89*	0.20*	0.47*	0.47*	1.44ns	1.48ns

Table 5: Effect of weed control methods and cropping densities on number of branches (nos./plant) in soybean in 2015 and 2016 cropping seasons (Mosogar).

	Week After Planting (WAP) 2015			Week After Planting (WAP) 2016		
Treatments	**8**	**10**	**12**	**8**	**10**	**12**
Weed control						
Unweeded	0.94a	1.49a	2.07a	1.27a	2.49a	2.66a
Hoe weeding (3&6WAP)	1.58b	2.00a	2.44a	1.96b	2.87a	3.29a
Pendimethalin (1.16 kg a.i./ha)	1.33a	1.78a	2.31a	1.50a	2.73a	2.92a
Fusilade forte (0.23kg a.i./ha)	0.97a	1.57a	2.20a	1.44a	2.63a	2.89a
Pm + Ff (1.16 + 0.23 kg a.i./ha)	1.16a	1.97a	2.41a	1.94b	2.82a	3.19a
LSD (0.05)	0.44	0.56	0.54	0.26	0.94	0.95
Density						
500,000	1.14a	1.65a	2.24a	1.31a	2.45a	2.58a
333,333	1.13a	1.75a	2.31a	1.54b	2.74a	3.03a
266,666	1.32a	1.88a	2.31a	2.02c	2.93a	3.37b
LSD (0.05)	0.34	0.43	0.42	0.20	0.73	0.74
Interaction						
WXD	0.76*	0.96*	0.94*	0.45*	1.62ns	1.64ns

Table 6: Effect of weed control and cropping densities treatments on yield and yield components of soybean in 2015 cropping season (Mosogar).

Treatments	Days to 50% Flowering	Pod nos. per Plant	Pod Weight per Plant(g)	Seed Weight per Plant (g)	100 Seed Weight (g)	Grain yield (Kg/ha)	Shelling (%)	Stover yield (t/ha)
Weed control								
Unweeded	62.6a	10.81a	3.36a	1.94a	9.57a	456.5a	54.6a	1.19a
Hoe weeding (3&6WAP	62.3a	40.58d	12.18e	5.94e	9.78a	1263.7d	52.3a	2.27d
Pendimethalin (1.16kg a.i./ha)	62.6a	27.16c	5.94c	3.67c	9.89a	1014.8c	61.9c	1.45b
Fusilade forte (0.23kg a.i./ha)	62.6a	18.43b	5.23b	2.80b	9.80a	787.4b	60.0c	1.28a
Pm+ Ff(1.16 + 0.23 kg a i/ha)	61.9a	25.84c	7.93d	4.50d	10.10a	1094.9cd	58.2bc	1.93c
LSD (0.05)	0.94	3.06	0.29	0.15	0.90	137.8	4.13	0.17
Density								
500,000	62.7a	22.75a	5.17a	3.51a	9.90a	1156.7c	58.2b	2.34c
333,333	62.2a	25.25b	7.01b	3.76b	9.83a	881.8b	45.2a	1.38b
266,666	62.2a	25.69b	8.60b	3.93c	9.75a	732.9a	68.8c	1.16a
LSD (0.05)	0.73	2.37	0.23	0.12	0.70	106.7	3.20	0.13
Interactions								
WXD	1.63ns	5.29*	0.51*	0.26*	1.36ns	238.7*	7.16*	0.30*

Table 7: Effect of weed control and cropping densities treatments on yield and yield components of soybean in 2016 cropping season (Mosogar).

Treatments	Days to 50% Flowering	Pod nos. per Plant	Pod Weight per Plant (g)	Seed Weight per Plant (g)	100 Seed Weight (g)	Grain yield (kg/ha)	Shelling (%)	Stover yield (t/ha)
Weed control								
Unweeded	59.3a	19.36a	5.89a	3.84a	11.73a	843.5a	65.4b	1.75a
Hoe weeding (3&WAP)	59.2a	41.16e	12.86e	7.82e	11.77a	1480..9e	61.5a	3.18d
Pendimethalin (1.16kg a.i./ha)	59.2	31.04c	8.91c	5.49c	11.20a	1215.5c	61.7a	2.16b
Fusilade forte (0.23kg a.i./ha)	59.2a	26.80b	7.69b	4.89b	11.49a	1029.4b	63.2a	2.09b
Pm + Ff (1.16+0.23kg a. i/ha)	59.2a	36.21d	10.31d	6.29d	11.07a	1354.4d	61.2a	2.64c
LSD (0.05)	0.49	1.56	0.21	0.21	0.92	80.3	2.02	0.08
Density								
500,000	59.2a	24.02a	7.64a	4.82a	11.91a	1423.2c	64.5b	3.08c
333,333	59.3a	34.25b	9.39b	5.78b	11.29a	1176.0b	61.5a	2.11b
266,666	59.3a	34.47b	10.35c	6.37c	11.15a	955.1a	61.8a	1.91a
LSD (0.05)	0.38	1.21	0.16	0.16	0.17	62.2	1.57	0.06
Interactions								
WXD	0.83ns	2.70*	0.36*	0,37*	1.59ns	139.0*	3.50*	0.13*