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The Effect of Different Weed Control Methods on Weed Infestation, Growth and Yield of Soybeans (Glycine Max (L) Merril) in the Southern Guinea Savanna of Nigeria

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Abstract- A field experiment was conducted during the 2012 and 2013 rainy season at the Kwara State University Teaching and Research Farm located in Malete. The aim was to determine the effect of different weed control methods on Weed infestation, growth and yield of soybeans (variety TGX 1448 – 2E). The experiment consisted of 8 treatments, namely, the application of metolachor at 1.5, 2.0 nd 2.5 kg a.i./ ha, pendimethalin at 1.5, 2.0 and 2.5 kg a.i./ha, a tank mixture of metolachlor + diuron at 1.5 + 0.5, 2.0 + 1.0 and 2.5 + 1.5 kg a.i./ha, pendimethalin + diuron at 1.5 + 0.5, 2.0 + 1.0 and 2.5 + 1.5 kg a.i./ha, metolachor at 2.0 kg a.i. /ha plus I supplementary hoe weeding (SHW) at 6 WAS, pendimethalin at 2.0 kg a.i. /ha plus supplimentary hoe weeding (SHW) at 6WAS, metolachlor + diuron at 1.0 +0.5 kg a.i. /ha plus ISHW, pendimethalin + diuron at 1.5 +0.5 plus ISHW at 6WAS, weeding at 3 and 6 WAS and a weedy check. Results show that all the herbicide treatments significantly reduced weed infestation compared with the weedy check. However, metolachlor + diuron integrated with ISHW was more effective than the application of only herbicides in the control of weeds throughout the crop life. This weed control method also resulted in significantly better growth and higher yield. Therefore for better growth and higher yields, metolachlor + diuron integrated with ISHW at 6 WAS is recommend to formers in the Southern Guinea Savanna of Nigeria.

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I. Introduction

Soybeans (*Glycine max* (L.) Merrill) account for more than 50% of the world oil seed output (Joshi, 2001). In tropical Africa, important countries known for soybean production are Zambia, Nigeria, Zimbabwe, Zaria, Rwanda, Uganda and Ethiopia. The average yield of soybean in Nigeria is 1,000kg ha^{-1}, while the world average yield is about 1,800 kg ha^{-1}. However, with proper management, is possible to obtain 2,500 kg ha^{-1} (Onwueme and Sinha, 1991).

Soybean is an important grain legume and source of vegetable protein (Anon, 1994). It is popular as golden been and has become the miracle crop of the 21st century. It serves the dual purpose of being grown both as an oil crop and pulse crop as well (Thakare *et al*. 2006). The crop has an average protein content of 40% and is more protein – rich than any of the common vegetable or animal food sources found in Nigeria (Dugje *et al*., 2009). In addition to its use as a source of protein and fodder, soybean can improve soil fertility by contributing to soil nitrogen through nitrogen fixation (Kureh *et al*., 2005). It can be used for soy-milk and vegetable oil, as soybean seed contains about 20% oil on a dry matter basis and this is 85% unsaturated and cholesterol – free (Dugje *et. al*; 2009).

Poor soybean yield in farmers' plots is attributable to weed-crop competition and low soil fertility (Sodangi *et al*., 2011). Jannink *et al*. (2000) reported that root and shoot interferences are the main factors that cause soybean grain yield reduction. Sodangi *et al*. (2006) reported a soybean grain yield loss of up to 99% due to weed infestation in the Sudan Savanna zone of Nigeria. This is because in the early growth stages, soybean is a poor competitor with fast growing weeds and if such weeds are not controlled, they may out grow the crop (Sodangi *et al*., 2007). Also, Daugovish *et a*l. (2003) reported that up to 80% yield loss of soybean may occur as a result of weed competition in many parts of the world.

Traditional manual weeding is the most popular method of weed control in Nigeria. This is, however, time consuming, labour – intensive, strenuous and generally expensive (Joshua and Gworgwor, 2000; Adigun and Lagoke, 2003). It is estimated that about 40 – 60% of production cost is spent on manual weeding (Remission, 1979). In addition to high cost, labour availability is uncertain, thus making timeliness of weeding difficult to attain, leading to greater yield loss (Adigun and Lagoke, 2003).

Herbicide use is one of the recent developments in crop production, more adapted to large scale production and labour saving (Anon, 1994). Other factors that have made chemical weed control more popular than manual weeding include reduction of drudgery in chemical weed Control, it protects crops from the adverse effects of early weed competition which can avert economic losses in soybean that needs early weed control in the first four weeks as this is the critical period of weed completion in soybean. It is a

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faster weeds control method than cultural weed control (Akobundu, 1987). Furthermore, the use of herbicides is more profitable than hoe-weeding in the production of most crops in Nigeria (Shrock and Monaco, 1980; Okereke, 1983; Sinha and Lagoke, 1984; Ogungbile and Lagoke, 1986; Adigun et al., 1993 and Imoloame et al., 2010). Their judicious use has been reported to reduce the cost of weed control, increased crop yields by reducing weed competition and consequently increased profitbality (Ogungbile and Sinha, 1982). A survey carried out by Ikuenobe (2005) and Imoloame (2013), showed that majority of farmers using herbicides indicated savings in labour and cost of production, better weed control and higher crop yields.

Considering the determination of Kwara State government to modernize agriculture and make farming more attractive through the reduction of drudgery, there is need to evaluate different methods of weed control in order to determine the one that will be most effective in weed control and result in higher soybean grain yield.

II. Materials and Methods

A field experiment was conducted during the 2012 and 2013 rainy season at the Teaching and Research Farm of Kwara State University, Malete, (lat. 08^0, 71'H; log.$04^0$44'E) at 365 above sea level. The objective was to determine the effect of some weed control methods on weed infestation, growth and yield of soybeans. The experiment consisted of 18 treatments, namely, the application of metolachlor at 1.5, 2.0 and 2.5 kg a.i./ha, pendimethalin at 1.5, 2.0 and 2.5 kg a.i./ha, a tank mixture of metolachlor + diuron at 1.5+0.5, 2.0+1.0 and 2.5+ 1.5 kg a.i./ha, pendimethalin + diuron at 1.5 + 0.5, 2.0 + 1.0 and 2.5 + 1.5 kg a.i./ha metolachlor at 2.0 kg a.i./ha plus I SHW at 6WAS, pendimethalin at 2.0 kg a.i./ha plus 1SHW at 6 WAS, metolachlor + diuron at 1.0 +0.5 plus ISHW, pendimethalin + diuron at 1.5 +0.5 plus I SHW at 6 WAS, weeding at 3 and 6 WAS and a weedy check. These treatments were laid out in a Randomized Complete Block Design (RCBD) and replicated three times. The variety of soybean that was used was TGX 1448 – 2E which was sown on 2nd of July 2012 and 28 June, 2013 and harvested on the 15th and 7th of November respectively. The crop was spaced at 40cm x 10cm to produce a plant population of 500,000. Herbicides were applied a day after planting with a CP3 knapsack sprayer which was calibrated to deliver 250 L /ha spray volume. Fertilizer was applied at the rate of 20 kg N, 20 kg P and 10 kg k_2O. These were provided with a compound fertilizer 15:15:15. The gross plot was 3x3m^2 while the net plot was 1.2_nx 3m^2. The outer rows were discarded while only the 5 inner rows were harvested and weighed. The parameters measured were plant height, weed dry matter, weed cover scores, crop vigour, phytotoxicity, 100 – seed weight and soybean grain yield. Data collected were subjected to analysis of variance and means were separated using Duncan's Multiple Range Test at 5% level of probability.

III. Result and Discussion

Weeds observed on the experimental farm included, *Celosia leptostachya Benth, Hyptis lanceolata Poir, Mariscus alternifolius* vahL (=M. unbellatus Vahl), Hyptis suaveolens Poit and *Leucas martinicensis occure* at high levels of infestation, *Daniellia oliveri commelina benghalensis, Cyperus esculentus, Cyperus roturdus, Brachiaria Lata*, Chloris pilosa, *Dactyloctenium aegytium Digitaria horizontalis, Pennisetum Pedicellatum and Rottboelia conchinchinensis*. Table 1 shows the effect of different methods of weed control on weed dry matter at 6 WAS and harvest. It shows that different methods of weed control significantly affected weed dry matter in both years and their means. Weeding twice at 3 and 6 WAS significantly reduced weed dry matter at 6 WAS compared with the other treatments in both years and the combined except. metolachlor at 1.5kga.i. /ha, pendimethalin at 2.0 and 2.5 kg a.i./ ha, a tank mixture of metolachlor + diuron at 2.0+1.0 and 2.5+1.5 kg a.i./ha, a tank mixture of pendimethalin + diuron at 2.5 + 1.5 kg a.i./ha, metolachlor at 2.0 Kg a.i. plus I SHW, metolachlor + duiron and pendimethalin + diuron at 1.5 +0.5 kg a.i./ha integrated with I SHW. Weedy check supported significantly higher weed infestation. However at harvest, metolachlor + diuron and pendimethalin + diuron at 1.5 + 0.5 kg a.i./ha integrated with 1 SHW at 6 WAS , two hoe weedings metolachlor and pendimethalin at 2.0 kg a.i./ha integrated with I SHW sustained their effectiveness in the control of weeds till harvest. Integrating metholachlor + diuron at 1.5 + 0.5 with I SHW at 6 WAS and pendimethalin at 2.0 kg a.i./ha plus 1SHW supported significantly lower weed dry mater in both years and the combined than the other weed control treatment except hoe weeding at 3 and 6 WAS pendimethalin at 2.0 kg a.i./ha in 2013 and metolachlor at 2.0 kg a.i./ha plus I SHW in 2012. This clearly underscores the importance of integrated weed management in enhancing weed control compared with the use of single weed control method. (Table 1). Also using only herbicides at the above doses were only effective in weed control up to 6 WAS. However they become ineffective with time.

The effect of different methods of weed control on weed cover scores at 6 WAS and at harvest is presented in table 2. Different methods of weed control significantly affected weed cover scores. At 6 WAS in the mean, metolachlor at 2.0 kg a.i.lha supported significantly lower weed cover score than the other treatments, except pendimethalin at 2.0 kg a.i./ha plus ISHW, two hoe weedings, pendimethalin at 1.5 +0.5 kg a.i./ha plus I SHW, metolachlor + diuron at 1.5 + 0.5 and 2.5 + 1.5 kg a.i./ha and pendimethalin + diuron at

2.5 + 1.5 kg a.i./ha. However at harvest herbicides alone poorly controlled weeds, while two hoe weeding resulted in comparable significantly lower weed cover with metolachlor + duiron and pendimethaline + duiron at 1.5 + 0.5 kg a.i./ha integrated with I SHW, and metolachlor or pendimethalin integrated with I SHW. Other herbicide treatments along with weedy check resulted in significantly higher weed cover scores in both years and their means. This result corroborates the findings of Peer (2013) that herbicide proved effective at higher rates when applied alone, however when combined with one hoe weeding, they were more effective, and that the initial achievement of limiting weed growth by the herbicides is maintained as hand weeding eliminates the fresh flush of weeds that may regenerate due to loss of persistence of herbicides applied alone. (Table 2) Also the integrated weed control method ensured early canopy closure which further suppressed late emerging weeds. This is in line with the report of (Gebharat and minor, 1983, murphy and Gossett, 1981; MIckelson and Runnur 1997, Yelverlon and coble, 1991) that if weeds are controlled within the first five weeks after sowing, the canopy of narrow-sown soybean can suppress late emerging weeds. Table 3.presents the effect of different methods of weed control on phytotoxicity of soybean at 2, 4 and 8 WAS. In 2013 at 2 WAS, it was only pendimethalin at 2.0 kg a.i./ha, a tank mixture of pendimethalin + duiron at higher dose and metolachlor at 2.0 kg a.i./ha plus I SHW that were significantly phytotoxic to soybean, however at time progressed to 4 WAS and 8 WAS this effect was neutralized. In the mean at 2 WAS, all the herbicide rates did not have any phytotoxic effect on soybean indicating that all the herbicides used were safe to be used for weed control in soybean (Table 3).

Table 4 presents the effect of different methods of weed control on soybean plant height at 6 WAS and at harvest. It shows that at 6 WAS, while different methods of weed control had no significant effect on soybean plant height in 2012, they affected soyabean plant height significantly in 2013 and the mean.

In both 2013 and the mean, metolachlor + diuron at 1.5 + 0.5 kg a.i./ha plus I SHW supported comparable significantly taller soybeans plants with other herbicides treatments and two hoe-weedings except pendimethalin at 2.0 and 2.5 in 2013 and the mean respectively, pendimethalin + diuron at 2.0 + 1.0 and pendimethalin + diuron at 1.5 + 0.5 kg a.i./ha plus supplementary hoe weeding in the mean and weedy check which supported significantly shorter soybean plants. However at harvest, all the weed control treatment produced significantly taller plants except pendimethalin at 2.0 kg a.i./ha, pendimethaline + diuron at 2.5 + 1.5 kg a.i./ha in 2013 and metolachlor and pendimethalin at 2.0 kg a.i./ha plus I SHW in the mean. Weedy check gave significantly shortest soybean plants. Plots treated with metolachlor + diuron at 1.5 +0.5 kg a.i./ha and other weed control treatments supported significantly taller soybean plants than the weedy check because of their ability to effectively control weeds which allowed the soyabean plants to utilize more nutrient, moisture and sunlight for better performance. The shortest soyabean plants were produced by the weedy check as a result of the greater intensity of weed competition with crop for growth resources which led to poor performance of the crop. The shorter soybean plants observed under pendimentalin at 2.0 kg a.i./ha in 2013 and could be due to the slight phytotoxicity of the herbicides at the early stage of crop growth which disappeared as the plant grew older.

Table 5, shows the effect of different methods of weed control on soybean crop vigour. It shows that different methods of weed control affect soybean crop vigour at 6WAS and at harvest in 2013 and the mean. A tank mixture of metolachlor + dluron at 1.5 + 0.5 kg a.i./ha plus I SHW produced significantly vigorous crops which were comparable with other weed control treatments except pendimethalin at 2.0 kg a.i./ha in 2013 and pendimethalin + duiron at 2.5 + 1.5 kg a.i./ha and weedy check in 2013 and the mean which gave significantly weaker crops. At harvest, similar observation was obtained with a tank mixture of matolachlor + diuron at 1.5 +0.5 kg a.i./ha plus ISHW producing significantly most vigorous crops in 2013 and the mean which was comparable to melolachlor at 2.0 kg a.i./ha, metolachlor + diuron at 1.5+ 0.5 and 2.0 + 1.0 kg a.i./ha, pendimethalin + diuron at 1.5+0.5 and 2.0+1.0 kg a.i.lha, and two hoe weedings. The other weed control treatments and the weedy check resulted in significantly weaker plants. Metolachlor + diuron at 1.5 + 0.5 kg a.i./ha plus I SHW consistently produced significantly most vigorous crops as a result of its greater ability of this weed control method to control weeds more effectively than other control methods. This made more growth resources to be available for use by the crops under this treatment resulting in a better performance.

The weedy check consistently supported significantly weaker crops at 6 WAS and harvest than the other weed control methods due to the greater weed competition with soybean crop which significantly reduced the amount of assimilates, nutrients, moisture and solar radiation utilized by the crop leading to poor performance.

Table 6, presents the effect to different methods of weed control on 100-seed weight and soybean grain yield. The effect of different methods of weed control on 100-seed weight was not significant in 2012 while it was significant in 2013 and their mean. In 2013 and the combined, tank mixture of metolachlor + diuron at 1.5 + 0.5 plus I SHW gave significantly heaviest soybean seeds which were comparable to metolachlor at 2.5 kg a.i./ha, pendimethalin at 1.5 kg a.i./ha pendimethalin + diuron at 1.5 +0.5 and 2.0 + 1.0 kg a.i./ha,

pendimethalin at 2.0 kg a.i./ha plus I SHW, pendimethalin + diuron at 0.5 +1.0 kg a.i./ha plus I SHW and two hoe weedings but significantly heavier than the rest of the weed control methods and weedy check. This further reveals the effectiveness of the above weed control methods to significantly reduce weed cover thereby minimizing weed competition with the soyabean crop leading to uptake of more nutrients, moisture and sunlight and assimilate for the production of heavier seeds.

Similarly, different methods of weed control affect soyabean grain yield significantly only in both years and their mean. In 2012 all the weed control methods resulted in comparable significant higher grain yield than the weedy check. However in 2013, a tank mixture of metolachlor + diuron at 1.5 +0.5 kg a.i./ha integrated with 1 SHW produced significant higher grain yield than all the other weed control methods, except two hoe weedings at 3 and 6 WAS. Similar trend was observed in the mean with a tank mixture of metolachlor + diuron at 1.5 + 0.5 kg a.i./ha producing significant higher yield which was comparable with other weed control methods except metolachlor at 1.5 and 2.0 kg a.i./ha, pendimethalin at 1.5 kg a.i./ha, metolachlor + duiron at 1.5 +0.5 kg a.i./ha and the weedy check which produced significantly lower soybean grain yields. Generally, 2012 recorded higher grain yields across treatments than 2013. In 2012, all the weed control methods produced significantly higher soybean grain yield than the weedy check because the weed control methods significantly reduced weed infestation compared to the weedy check which allowed crops to utilize more growth factors for better growth. However in the weedy check weed competition for growth resources with the soyabean crop was more intense, resulting in yield losses between 76.80% in 2012 and 89.3% in 2013. The higher percentage of losses and lower grain yields recorded in 2013 compared to 2012, could be due to the prolonged period of drought that was experienced in 2013 which limited the amount of moisture, nutrients and assimilate that were taken up by the crop. This situation was worsened by the greater weed cover that was observed in the plots probably due to the reduction of the potency of the herbicides as a result of the drought condition.

Metolachlor + diuron at 1.5 + 0.5 kg a.i. /ha and weeding at 3 and 6 WAS proved to be more effective than the other weed control methods as a result of their greater ability to continuously reduce weed infestation at the critical period of weed interference of soybean, thereby making more growth resources available to soybean for utilization. This led to significantly more vigorous crops, taller plants, heavier seed weight and higher grain yield. This result is similar to the findings of Peer et al. (2013) that hand weeding twice and both fluchoralin and pendimethalin integrated with hand weeding recorded far superior yields of soybean seed. Also, a number of researchers like Veeramani et al. (2001) held similar views and reported more pods with integrated use of herbicides with hand weeding. Uncontrolled weeds resulted in 89.3% and 76.8% soyabean losses in 2012 and 2013 respectively. This lis similar to the findings of Sodangi et al. (2006) that soybean grain yield loss of up to 99% was due to weed infestation in the Sudan Savanna Zone of Nigeria.

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Table 1 : Influence of different methods of weed control on weed dry matter, 2012 and 2013.

Treatment	Rate kg a.i./ha	WEED DRY MATTER					
		6WAS			HARVEST		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	246.7bc	144.0cd	195.3bc	1777.8ab	1022.0ab	1399.9ab
Metolachlor	2.0	428.0ab	146.3cd	287.1b	955.6ab	999.9ab	977.7ab
Metolachlor	2.5	460.9ab	168.9bc	314.9b	1911.1a	666.6bc	1288.8ab
Pendimethalin	1.5	435.6ab	128.5cd	282.0b	1627.0ab	633.2bc	1130.1ab
Pendimethalin	2.0	164.0bc	197.1ab	180.6bc	1555.6ab	822.2ab	1188.9ab
Pendimethalin	2.5	216.9bc	187.3ab	202.1bc	1288.9ab	1144.4ab	1216.7ab
Metolachlor + diuron	1.5+0.5	206.2bc	117.7cd	162.0bc	1422.6ab	833.3ab	1128.9ab
Metolachlor + diuron	2.0+1.0	276.0bc	136.0cd	206.0bc	1511.5ab	684.4bc	1098.0ab
Metolachlor + diuron	2.5+1.5	192.0bc	128.9cd	160.4bc	1018.1ab	955.6ab	986.8ab
Pendimethalin+diuron	1.5+0.5	393.3ab	155.7bc	274.5b	1533.3ab	777.8bc	1155.5ab
Pendimethalin+diuron	2.0+1.0	353.3ab	268.9ab	311.1b	1044.5ab	788.9bc	916.7ab
Pendimethalin+diuron	2.5+1.5	175.1bc	162.7bc	168.9bc	333.7ab	733.3bc	533.5ab
Metolachlor +I SHW	2.0	212.9bc	129.1cd	171.0bc	62.6cd	300.0de	181.3de
Pendimethalin+ I SHW	2.0	445.8ab	117.5cd	281.7b	14.0d	188.9ef	101.4ef
Metolachlor +diuron+I SHW	1.5+0.5	252.9bc	157.8bc	205.3bc	1.0d	155.5f	78.3f
Pendimethalin+diuron+ISHW	1.5+0.5	176.0bc	164.4bc	170.2bc	222.9bc	377.7cd	300.3bc
Weeding at 3 and 6 WAS	-	57.3c	54.9d	56.1c	333.7ab	155.9f	244.8cd
Weedy Check	-	622.2a	291.3a	456.8a	1377.8ab	1422.2a	1400.0a
SE(±)		26.63	9.9	2.01	150.50	59.61	12.3

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 2 : Influence of different methods of weed control methods on weed cover scores, 2012 and 2013.

Treatment	Rate kg a.i./ha	WEED COVER SCORES					
		6WAS[1]			HARVEST		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	4.0bc[2]	7.0b	5.5b	6.7ab	9.7a	8.2ab
Metolachlor	2.0	3.7bc	4.5bc	4.1bc	6.0ab	9.0a	7.5bc
Metolachlor	2.5	4.3bc	3.2e	3.8bc	4.2cd	8.7a	6.4bc
Pendimethalin	1.5	3.3bc	3.7de	3.5cd	6.7ab	8.8a	7.6bc
Pendimethalin	2.0	1.8cd	6.2bc	4.0bc	5.3bc	8.3a	6.8bc
Pendimethalin	2.5	4.0bc	6.7bc	5.3bc	6.7ab	8.0a	7.3bc
Metolachlor + diuron	1.5+0.5	1.8cd	3.5de	2.7e	3.2de	7.7ab	5.4e
Metolachlor + diuron	2.0+1.0	2.3 bc	4.8bc	3.6cd	6.3ab	8.0a	7.2bc
Metolachlor +diuron	2.5+1.5	1.8cd	2.8e	2.3e	3.5de	7.7a	5.6de
Pendimethalin+ diuron	1.5+0.5	4.0bc	5.3bc	4.7bc	8.7ab	8.7a	8.7ab
Pendimethalin+ diuron	2.0+1.0	2.8bc	4.7bc	3.8bc	7.8ab	8.0a	7.9ab
Pendimethalin+ diuron	2.5+1.5	1.7cd	5.0bc	3.3de	3.7cd	8.0a	5.8cd
Metolachlor +I SHW	2.0	1.3d	3.8cd	2.6e	1.8ef	3.7c	2.8f
Pendimethalin+ I SHW[3]	2.0	2.8bc	2.8e	2.8de	1.5f	4.7b	3.1f
Metolachlor + diuron+I SHW	1.5+0.5	5.0b	3.1e	4.1bc	3.8cd	2.3c	3.1f
Pendimethalin+diuron+ISHW	1.5+0.5	2.0cd	4.5bc	3.3de	1.7f	3.0c	2.3f
Weeding at 3 and 6 WAS	-	1.8cd	5.0bc	3.4de	1.3f	3.5c	2.4f
Weedy Check	-	9.0a	9.8a	9.4a	10.0a	1.0a	10.0a
SE(±)		0.30	0.49	0.03	0.43	0.39	0.05

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 3 : Influence of different methods of weed control on phytotoxity of soybean

Treatment	Rate kg a.i./ha	PHYTOTOXICITY RATING								
		2WAS			4WAS			8WAS		
		2012	2013	Mean	2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	1.0a	1.0b	1.0b	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor	2.0	1.0a	1.0b	1.0b	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor	2.5	1.7a	1.0b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin	1.5	3.7a	1.6b	2.6ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin	2.0	1.0a	2.7a	1.8ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin	2.5	3.7a	2.3b	3.0a	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor +diuron	1.5+0.5	2.0a	1.0b	1.5ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor +diuron	2.0+1.0	3.0a	1.0b	2.0ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor +diuron	2.5+1.5	1.6a	1.3b	1.5ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+ diuron	1.5+0.5	3.3a	1.3b	2.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+ diuron	2.0+1.0	2.3a	1.7b	2.0ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+ diuron	2.5+1.5	2.0a	3.3a	2.7ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor +I SHW	2.0	2.0a	3.3a	2.7ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+ I SHW	2.0	1.3a	1.3b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Metolachlor + diuron+I SHW	1.5+0.5	1.7a	1.0b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Pendimethalin+diuron+ISHW	1.5+0.5	3.3a	1.3b	2.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Weeding at 3 and 6 WAS	-	1.7a	1.0b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
Weedy Check	-	1.7a	1.0b	1.3ab	1.0a	1.0a	1.0a	1.0a	1.0a	1.0a
SE(±)		0.24	0.12	0.02	0.11	0.0	0.00	0.0	0.0	0.00

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 4 : Influence of different methods of weed control on plant height of soybean, 2012 AND 2013.

Treatment	Rate kg a.i.lha	PLANT HEIGHT (cm^2)					
		6WAS			HARVEST		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	26.5a	23.8ab	25.2ab	53.1a	37.7ab	45.4ab
Metolachlor	2.0	28.7a	25.2ab	26.9ab	49.9a	39.6ab	44.8ab
Metolachlor	2.5	25.9a	23.8ab	24.9ab	50.0a	40.1ab	45.1ab
Pendimethalin	1.5	25.6a	25.3ab	25.4ab	43.8a	43.9ab	43.9ab
Pendimethalin	2.0	28.2a	20.7bc	24.5ab	51.5a	28.1cd	39.8cd
Pendimethalin	2.5	20.9a	24.3ab	22.6bc	45.3a	39.1ab	42.2ab
Metolachlor + diuron	1.5+0.5	27.1a	25.7ab	26.4ab	48.6a	43.4ab	46.0ab
Metolachlor + diuron	2.0+1.0	23.5a	26.8a	25.1ab	47.7a	48.5ab	48.1ab
Metolachlor + diuron	2.5+1.5	28.5a	25.0ab	26.7ab	57.0a	40.1ab	48.6a
Pendimethalin+ diuron	1.5+0.5	25.5a	26.3ab	25.9ab	50.2a	40.6ab	45.4ab
Pendimethalin+ diuron	2.0+1.0	23.7a	23.3ab	23.5bc	45.0a	39.3ab	42.1ab
Pendimethalin+ diuron	2.5+1.5	27.2a	23.3ab	25.2ab	51.7a	32.7bc	42.2ab
Metolachlor +I SHW	2.0	23.4a	23.7ab	23.5ab	42.4a	38.1ab	40.3bc
Pendimethalin+ I SHW	2.0	23.8a	24.7ab	24.3ab	42.5a	37.8ab	40.1bc
Metolachlor + diuron+I SHW	1.5+0.5	29.6a	28.5a	29.1a	49.5a	50.7a	50.1a
Pendimethalin+diuron+ISHW	1.5+0.5	21.8a	23.5ab	22.7bc	44.2ab	43.1ab	43.7ab
Weeding at 3 and 6 WAS	-	23.9a	28.9a	24.5ab	48.8a	44.1ab	43.0ab
Weedy Check	-	20.1a	18.1c	21.0c	41.9a	24.5d	36.7d
SE(±)		0.71	0.31	0.05	1.03	1.15	0.09

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 5 : Influence of different weed control methods on soybean crop vigour, 2012 and 2013.

Treatment	Rate kg a.i./ha	CROP VIGOUR					
		6 WAS			9 WAS		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	8.2a	8.0ab	8.1a	8.2a	7.5bc	7.8ab
Metolachlor	2.0	7.5a	8.2ab	7.8ab	8.2a	7.8ab	8.0ab
Metolachlor	2.5	7.5a	8.0ab	7.8ab	8.5a	7.2bc	7.8ab
Pendimethalin	1.5	7.2a	7.7ab	7.4ab	7.0a	7.0bc	7.0d
Pendimethalin	2.0	8.2a	7.0bc	7.6ab	9.2a	7.0bc	8.1ab
Pendimethalin	2.5	7.5a	7.2ab	7.3ab	7.3a	6.8c	7.1cd
Metolachlor + diuron	1.5+0.5	7.7a	8.3ab	8.0a	8.5a	8.0ab	8.3ab
Metolachlor + diuron	2.0+1.0	7.2a	8.5ab	7.8ab	7.7a	8.2ab	7.9ab
Metolachlor + diuron	2.5+1.5	8.2a	8.0ab	8.1a	8.7a	7.3bc	8.0ab
Pendimethalin+ diuron	1.5+0.5	7.8a	8.2ab	8.0a	8.5a	7.8ab	8.2ab
Pendimethalin+ diuron	2.0+1.0	7.3a	7.8ab	7.6ab	7.8a	8.0ab	7.9ab
Pendimethalin+ diuron	2.5+1.5	7.7a	6.3cd	7.0bc	8.3a	6.8c	7.6bc
Metolachlor +I SHW	2.0	7.5a	7.5ab	7.5ab	7.8a	7.7ab	7.8bc
Pendimethalin+ I SHW	2.0	7.3a	7.5ab	7.4ab	7.8a	7.3bc	7.6bc
Metolachlor + diuron+I SHW	1.5+0.5	7.3a	8.8a	8.1a	8.3a	9.2a	8.8a
Pendimethalin+ diuron+I SHW	1.5+0.5	7.2a	7.8ab	7.5ab	7.7a	7.5bc	7.6bc
Weeding at 3 and 6 WAS	-	7.5a	8.7ab	8.1a	7.5a	8.5ab	8.0ab
Weedy Check	-	7.8a	5.2d	6.5c	7.0a	4.3d	5.7e
SE(±)		0.10	0.16	0.01	0.15	0.16	0-01

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

Table 6 : Influence of different methods of weed control on 100-seed weight and grain yield (kg/ha), 2012 and 2013.

Treatment	Rate kg a.i./ha	100-seed weight (g)			Grain Yield (kg/ha)		
		2012	2013	Mean	2012	2013	Mean
Metolachlor	1.5	13.3a	13.9de	13.6b	1764.7ab	239.8cd	1002.3bc
Metolachlor	2.0	13.1a	14.4bc	13.8ab	1759.7ab	255.5cd	1007.6bc
Metolachlor	2.5	13.6a	15.1ab	14.3ab	2427.2ab	283.2cd	1355.2ab
Pendimethalin	1.5	13.4a	15.3ab	14.3ab	1345.8bc	378.9cd	862.3cd
Pendimethalin	2.0	13.4a	13.7e	13.6b	2658.7a	208.1cd	1433.4ab
Pendimethalin	2.5	12.9a	14.0de	13.5b	1967.6ab	276.6cd	1122.1ab
Metolachlor + diuron	1.5+0.5	13.1a	14.3bc	13.7b	1893.3ab	285.5cd	1089.7bc
Metolachlor + diuron	2.0+1.0	13.0a	14.4bc	13.7b	1961.3ab	481.6bc	1221.5ab
Metolachlor + diuron	2.5+1.5	13.6a	14.2bc	13.9ab	1946.8ab	331.8cd	1139.3ab
Pendimethalin+ diuron	1.5+0.5	13.6a	14.7ab	14.1ab	2384.0ab	393.1cd	1388.5ab
Pendimethalin+ diuron	2.0+1.0	13.6a	14.7ab	14.1ab	1835.4ab	556.6bc	1196.0ab
Pendimethalin+ diuron	2.5+1.5	13.6a	14.2cd	13.9ab	2340.9ab	268.5cd	1304.7ab
Metolachlor +I SHW	2.0	13.4a	14.5bc	14.1ab	2585.6a	606.6bc	1596.1ab
Pendimethalin+ I SHW[3]	2.0	13.5a	14.7ab	14.1ab	2320.2ab	447.7bc	1384.0ab
Metolachlor +diuron+I SHW	1.5+0.5	13.7a	15.8a	14.7a	2397.8ab	1013.1a	1705.4a
Pendimethalin+ diuron+I SHW	1.5+0.5	13.1a	15.5ab	14.2ab	2320.0ab	560.5bc	1440.2ab
Weeding at 3 and 6 WAS	-	13.3a	15.3ab	14.2ab	2345.5ab	803.7ab	1574.6ab
Weedy Check	-	13.3a	13.9de	13.5b	623.6c	108.2d	365.9d
SE(±)		0.10	0.11	0.01	86.48	37.71	6.69

I=Weeks after sowing 2=columns with the same letters are not significantly different at 5% level of probability according to Duncan's Multiple Range Test (DMRT) 3= Supplementary hoe weeding.

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