Journal of Agricultural Sciences
Vol. 64, No. 3, 2019
Pages 265-278

https://doi.org/10.2298/JAS1903265D
UDC: 632.51:633.853.52(669)"2016/2017"
632.954(669)"2016/2017"
Original scientific paper

ECONOMICS OF ROW SPACING AND INTEGRATED WEED MANAGEMENT IN SOYBEAN (*GLYCINE MAX* L.)

Olumide S. Daramola[1*], Olusegun R. Adeyemi[1], Joseph A. Adigun[1] and Christopher O. Adejuyigbe[2]

[1]Department of Plant Physiology and Crop Production,
Federal University of Agriculture, Abeokuta
[2]Department of Soil Science, Federal University of Agriculture, Abeokuta

Abstract: The high cost of cultivation and weed management are major limiting factors to increasing soybean productivity and net returns. Field experiments were conducted in 2016 and 2017 at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta to evaluate the economic performance of different row spacings and integrated weed management system in soybean. Three row spacings (50, 75 and 100 cm) as the main plots and six weed control methods and a weedy check as sub-plot treatments were accommodated in a split-plot arrangement of a randomized complete block design with three replications. There was a significant reduction in weed biomass with a reduction in row spacing from 100 cm to 75 cm and 50 cm. Furthermore, the cost of production, grain yield and gross profit increased with a reduction in row spacing from 100 to 75 and 50. When soybean was sown at 50-cm row spacing, the application of Probaben 400EC (metolachlor 20% w/v + prometryn 20% w/v) or Butachlor 60EC (butachlor) at 2.0 kg a.i/ha each followed by supplementary hoe-weeding at 6 weeks after sowing (WAS) resulted in the highest yield of 2301–2484 kg/ha and total revenue of 2129–1972 $/ha. Conversely, three hoe-weedings resulted in the highest yield of 2155–2081 kg/ha and total revenue of 1848–1783 $/ha for crops grown at 75- and 100-cm row spacings. Despite the higher yield and revenue obtained with three hoe-weedings for crops grown at 75- and 100-cm row spacings, the gross profit and benefit-cost ratios obtained were lower than those obtained with herbicide treatments applied alone or followed by supplementary hoe-weeding. In terms of profitability, soybean planted at 50-cm row spacing and treated with Probaben 400EC at 2.0 kg a.i/ha followed by supplementary hoe-weeding gave the highest gross profit of 1479 $/ha. Two or three hoe-weedings in soybean planted at narrow-row (50 cm) spacing did not guarantee the highest yield, but rather increased the cost of weed control. This study suggests that narrow-row spacing (50 cm) and pre-emergence herbicides will help to reduce the number of

*Corresponding author: e-mail: olumidedara01@gmail.com

hoe-weedings and consequently the high cost of production required for optimum yield and increase profitability in soybean production.

Key words: economics, row spacing, soybean, integrated weed management, gross profit.

Introduction

The production of soybean is increasing in Sub-Saharan Africa (SSA) due to its growing demand as a cheap source of protein (40%) and oil (20%) for human diet and animal feed and raw material for industry (Joubert and Jooste, 2013). In addition, it improves soil fertility by fixing atmospheric nitrogen for its own use and the benefit of intercropped cereals and subsequent crops in rotation (Ronner et al., 2016). Hence, soybean cultivation promotes economic, social and ecological development in Africa.

Nigeria is the second largest producer of soybean in SSA after South Africa with an average production of 680,000 tones (Khojely et al., 2018). Soybean production presents a great potential to meet the food and protein need and improve the livelihood of millions of smallholder farmers in Nigeria and other parts of SSA. However, weeds are considered a major constraint to soybean production in Nigeria and other soybean producing countries (Sodangi et al., 2006; Vivian et al., 2013). A survey of crop pests in SSA has earlier revealed that weeds are the most deleterious pest in all zones studied (Oerke and Dehne, 2004). About 37% of attainable soybean production is endangered by weed competition worldwide compared to 22% by pathogens, viruses and animal pests (Oerke and Dehne, 2004). Between 77% and 90% reduction in the potential yield of soybean was reported due to weed infestation in different zones in Nigeria (Sodangi et al., 2006; Imoloame, 2014). Ultimately, weed infestation limits economic benefit and reduces farmers' income from soybean production in SSA. Even with advanced technologies and improved varieties, farmers record high losses as a result of weed interference. Economic losses due to weed infestation in soybean vary with the cost of hoe-weeding, chemical or cultural methods of control that must be used (Sodangi et al., 2006). In the United States, for instance, weeds are reported to cause losses of several millions of US dollars yearly (Vivian et al., 2013), while soybean growers in the tropics lose about 1.8 million dollars annually due to weed infestation (Jannink et al., 2000).

Hoe-weeding is the predominant weed control method used in Nigeria. However, this method is very cumbersome and generally expensive because of the high price of labor which takes about 40 to 60% of the total cost of production (Adigun and Lagoke, 2013). In addition to high cost, labor availability is uncertain during the critical period of weed control which results in delayed weeding in a large portion of the planted crops after they have suffered irrevocable damage from weeds (Adigun, 2005). Herbicide use, on the other hand, although efficient, does not provide full-season weed control when used alone, and a single herbicide application may not control the entire weed spectrum (Chauhan et al., 2013). In addition, uncontrolled use of herbicides for weed control results in the increased number of herbicide-resistant weeds, shift in weed spectrum, environmental contamination and impacts on human health (Labrada, 2002). Therefore, farmers are becoming increasingly interested in more comprehensive weed management that would decrease their dependence on herbicides and multiple hoe-weedings as well as reduce the cost of weed control. There has been increased interest recently in the application of cultural approaches in integrated weed management systems (Chauhan and Johnson, 2010; Adigun et al., 2017). Among cultural practices, row spacing and/or seed rate is of immense significance, because it influences crop-weed interactions and crop competitiveness with weeds and therefore will affect weed management and cost of weed control (Knezevic et al., 2013). Soybean grown in narrow rows has been reported to have high competitive ability and quicker canopy cover with subsequence smothering and suppression of weed growth (Cox and Cherney, 2011). Hence, combining these weed control components with the reduced number of hoe-weedings and/or herbicide applications within the context of integrated weed management could help to improve weed control efficiency, reduce the high cost associated with multiple hoe-weeding or herbicide applications and increase soybean yield. Although some studies (Sodangi et al., 2006; Imoloame, 2014; Adigun et al., 2017) have earlier reported increased weed control efficiency and higher yields with integrated weed management, economic consideration, particularly profit is more important to farmers in driving the adoption of agricultural innovation (Pannell et al., 2006). It has also been reported that practices with the best yield may not necessarily translate to the best economic benefit to farmers (Sepat et al., 2017). Hence, this study was conducted to evaluate the economic performance of weed management methods using hoe-weeding, herbicides or their combination in soybean planted at 50-cm, 75-cm and 100-cm row spacings.

Material and Methods

The study was conducted at the Teaching and Research Farm of the Federal University of Agriculture, Abeokuta, Nigeria (7^{o} 15′ N, 3^{o} 23′ E 159 m above sea level) during the cropping seasons of 2016 and 2017 in the forest-savanna transition zone of South-West Nigeria. In both years, the experimental site was disc-plowed and harrowed at the two-week interval, pulverized and leveled manually. The site received an average rainfall of 607.1 mm with a mean temperature of 26.1 to 28.3 throughout the period of crop growth in both years of experimentation. The soils of the fields in both years had a sandy loam texture, pH of 7.7 and 7.5; organic matter of 2.5 and 2.1% and nitrogen of 0.25 and 0.21% in 2016 and 2017, respectively.

Gross and net plot sizes were 4.5x3.0 m^2 and 3.0 x 3.0 m^2, respectively. A late maturing (120-day duration) semi-determinate and high yielding soybean cultivar – TGX 1448-2E recommended for South-West Nigeria was planted on July 14^{th} and 12^{th} in 2016 and 2017, respectively. The treatments comprised three inter-row spacings of 50 cm, 75 cm and 100 cm equivalent to 100, 80 and 60 kg/ha seeding rates, respectively, which were the main plot treatments within the split-plot design with three replications. The sub-plot treatments comprised seven weed control methods: pre-emergence application of Probaben 400EC at 2 kg a.i/ha, pre-emergence application of Probaben at 2 kg a.i/ha followed by supplementary hoe-weeding at 6 weeks after sowing (WAS); pre-emergence application of butachlor 60EC at 2.0 kg a.i/ha; pre-emergence application of butachlor 60EC at 2.0 kg a.i/ha followed by supplementary hoe-weeding at 6 WAS; two hoe-weedings at 3 and 6 WAS; three hoe-weedings at 3, 6 and 9 WAS and the weedy check. Herbicides were applied pre-emergence, one day after sowing of soybean with a knapsack sprayer (CP 15, Hozelock-Exel, Cedex, France) in a spraying volume of about 250 l/ha using a deflector nozzle at a pressure of 2.1 kg/cm^2. Weed samples from each treatment were collected from two 0.5 m^2 quadrates per plot and were dried in an oven at 70°C for 72 h to determine the cumulative weed dry matter production at harvest. Soybean grain yield was obtained from the net plot after threshing the plants. The resulting grain weight in kg at 12.5% moisture content was expressed in kg/ha. Data collected were subjected to the analysis of variance (ANOVA) using the procedures of Genstat. Treatment means were compared using the least significant difference test (LSD) at 5% probability level.

Economic analysis of row spacing and weed management methods used was carried out based on gross profit analysis using partial budgeting. Economics of various row spacing, hoe-weeding and chemical weed control methods was calculated by working out expenditure on different aspects of cultivation and gross income under different treatments. The net return and cost-benefit ratio were also calculated to ascertain the viability of the treatments. The prevailing farm gate price for various cultivation operations, the input used and labor engaged due to treatments were used. Data averaged over two years of the study were used to estimate the profitability of row spacing and different weed control methods. The cost of cultivation was calculated based on the cost of land preparation, seeds, planting and weed control and harvesting. The revenue produced from each treatment was obtained by multiplying the yield by the market price.

TR = Quantity × Price (Osipitan et al., 2018).

TR is total revenue per hectare ($/ha), Quantity is total soybean grain yield harvested in kilograms per hectare (kg/ha), Price is the market price of soybean

($/kg). Gross profit for each weed management method and row spacing was calculated by deducting the total cost of cultivation from the return.

GP = TR – TVC (Osipitan et al., 2018).

GP is the gross profit per hectare ($/ha), TVC is the total variable cost of cultivation ($/ha). The benefit-cost ratio for each treatment was calculated by dividing gross profit by the total cost of cultivation:

Benefit-cost ratio = GP/TVC.

GP and TVC were as defined above (Osipitan et al., 2018).

Results and Discussion

The results of this study (data averaged over two years) showed a substantial increase in the cost of production (from $461.2 to $637.7 ha^{-1}), grain yield (from 1512 to 1937 kg ha^{-1}) and gross profit ($835 to $1023 ha^{-1}) with a reduction in row spacing from 100 cm to 75 cm and 50 cm. However, weed biomass was reduced significantly with a reduction in row spacing (Table 1). The labor costs for land preparation was the same for the three row spacings in both years, thus differences in the cost of production were largely due to variations in the cost of seed, labor required for planting, as well as the cost of hoe-weeding and harvesting which varied between the three row spacings. Planting soybean at 50-cm row spacing required 20 to 40 kg more seed at a cost of $18 to $36/ha than at 75-cm and 100-cm row spacings. Similarly, 75-cm row spacing required 20 kg more seed at $18/ha than 100-cm row spacing. The cost of planting at 50-cm row spacing was $43 to $65/ha higher than at 75-cm and 100-cm row spacings. Similarly, the cost of planting at 75-cm row spacing was $22/ha higher than at 100-cm row spacing. The higher cost of planting at 50-cm row spacing was associated with the higher seed rate and the number of rows required for 50-cm row spacing, which is relatively more labor demanding. The same reason could also be adduced for the higher labor cost required for harvesting soybean planted at 50-cm row spacing. In addition, 50-cm row spacing required more labor for weeding at a cost of $11ha^{-1} than 75-cm and 100-cm row spacings (Table 1). This is associated with a lodging which occurred at 50-cm row spacing, making manual weeding relatively more labor demanding. The increased cost of cultivation associated with reduced row spacing in this study is similar to the observation of Osipitan et al. (2018) in cowpea.

On the other hand, however, a reduction in row spacing from 100 cm to 75 and 50 cm resulted in an increased population of soybean plants per hectare with a subsequent increase in grain yield, total revenue and gross benefit. An increase in grain yield with a reduction in row spacing could also be attributed to better weed suppression and reduced weed competition for resources, occasioned by early canopy closure at narrow compared to wide-row spacing. These results are in agreement with that of Bhagirath et al. (2016) where mungbean spaced at 25 and 50 cm suppressed weed growth and had higher grain yield than those spaced at 75-cm wide-row spacing. In maize, similar results of more effective weed suppression by reduced row spacing were obtained by Simić et al. (2012). Furthermore, the revenue from narrow-row spacing was higher than from wide-row spacing. The market price used for the budget estimation for the three row spacings was the same, thus, differences in revenue were largely due to variations in yield levels of each row spacing. The high yield level of crops planted at 50-cm row spacing was a major factor that accounts for their relatively high harvesting labor compared to crops planted at 75-cm and 100-cm row spacings.

Table 1. The economic analysis of row spacing and weed management methods for soybean cultivation (data averaged for two trials).

Treatments	Seed and seed treatment	Land preparation	Planting	Weed control	Harvesting/ threshing	Total	Weed biomass (kg/ha)	Yield (kg/ha)	Total revenue	Gross profit	Benefit-cost ratio
Row spacing											
50 cm	91.4	77.1	128.6	211.9	128.6	637.7	2061.9	1937.4	1660.2	1023.0	1.7
75 cm	73.1	77.1	85.7	200.6	85.7	522.3	3319.7	1718.6	1472.3	950.3	1.9
100 cm	54.9	77.1	64.3	200.6	64.3	461.2	4222.3	1512.3	1296	835.3	1.9
Lsd (5%)							129.5	56.5			
Weed control methods											
Probaben at 2.0 kg a.i/ha	73.1	77.1	92.9	46.4	92.9	382.4	3275.2	1728.1	1481.1	1099.2	2.9
Probaben at 2.0 kg a.i/ha fb shw	73.1	77.1	92.9	220.0	92.9	556.0	2218.4	2098.4	1798.0	1242.3	2.2
Butachlor at 2.0 kg a.i/ha	73.1	77.1	92.9	55.7	92.9	391.7	3106.6	1756.3	1505.1	1113.3	2.8
Butachlor at 2.0 kg a.i/ha fb shw	73.1	77.1	92.9	230.0	92.9	566.0	2239.5	2043.5	1751.1	1185.4	2.1
2 hoe-weedings at 6 and 9 WAS	73.1	77.1	92.9	351.4	92.9	687.4	3126.3	1780.5	1526.0	839.6	1.2
3 hoe-weedings at 3, 6 and 9 WAS	73.1	77.1	92.9	527.1	92.9	863.1	2615.3	2061.3	1766.6	903.0	1.0
Weedy check	73.1	77.1	92.9	0.0	92.9	336.0	5820.2	589.0	505.1	169.2	0.5
Lsd (5%)							197.7	120.6			

a.i – active ingredient, shw – supplementary hoe-weeding, WAS – weeks after sowing.

All the weed management methods incurred higher costs of cultivation than the weedy check as a result of the cost of weed control (Table 1). Of all the weed control methods, three hoe-weeding treatments incurred the highest total cost ($863) as a result of the accumulated cost of hoe-weeding which is usually expensive (Table 1). On the other hand, weedy plots where weeds were not controlled throughout the crop life cycle had the lowest total variable cost (Table 1). This was consistent across the three row spacings of 50 cm, 75 cm and 100 cm used in this study (Table 2). This finding has confirmed other reports that the cost of weed control takes the bulk of total production cost in many field crops (Adigun and Lagoke; Chikoye, 2007).

Irrespective of the row spacing used, pre-emergence application of Probaben 400EC or butachlor 60EC each alone at 2.0 kg a.i ha $^{-1}$ or followed by supplementary hoe-weeding at 6 WAS resulted in a lower cost of cultivation than two and three hoe-weedings (Table 2). The relatively lower cost incurred by herbicide treatments compared to hoe-weeding may be attributed to a reduction in labor requirement for herbicide application compared with the labor required for hoe-weeding. Comparisons of the economics of different weed control technologies have earlier indicated that the overall reduction in production costs associated with herbicides is caused by a massive reduction in the labor required for weeding from 39.2 to 1.3 person-days per hectare (Overfield et al., 2001). The use of herbicides to remove weeds required only 2 hours of labor per hectare, whereas the optimal amount of hand-weeding required per hectare is estimated to be 400 hours (Gouse et al., 2006). The result of this study has corroborated the findings of Patil et al. (2014) that manual weeding is very expensive, strenuous and causes a lot of drudgery.

All the weed control methods resulted in higher soybean grain yield than the weedy check across the 50-, 75- and 100-cm row spaced plots (Table 2). This result is in agreement with the earlier report of Sodangi et al. (2006) that allowing weeds to compete with soybean substantially reduced yield. The results are also akin to those reported by Patil et al. (2014) and many others who reported an increased yield of soybean due to various weed control treatments owing to the increased availability of nutrient, light and space. When the crops were planted at 50-cm row spacing, pre-emergence application of herbicides (Probaben 400EC or butachlor 60EC) at 2.0 kg a.i/ha each followed by supplementary hoe-weeding at 6 WAS resulted in the highest yield (2301 to 2484 kg/ ha) and total revenue ($1972 to $2129/ha). However, when the crops were planted at 75- and 100-cm row spacings, three hoe-weeding treatments resulted in the highest yield (2081 to 2155 kg/ha) and total revenue ($1783 to $2081/ha). This showed that application of these herbicides followed by single hoe-weeding was only adequate to give optimum yield and revenue in narrow- (50 cm) but not in intermediate- (75 cm) and wide-row (100 cm) soybean, probably because soybean planted in wide-row spacing had higher late-season weed infestation as a result of poor canopy closure and more space available for weed growth, and hence required a longer period of weed control than soybean planted in narrow rows. These results have corroborated the report of Culpepper (2006) that wide-row spacing requires multiple hoe-weedings to achieve a reasonable level of weed control and good yield. On the other hand, however, for the narrow-row spacing of 50 cm, increasing the number of hoe-weedings to two or three times did not guarantee the highest yield, total revenue or cost-benefit ratio, but rather increased the cost of weed control (Table 2). Higher grain yield obtained with pre-emergence herbicide followed by supplementary hoe-weeding at 50-cm row spacing could be attributed to early weed control by the pre-emergence herbicide, early canopy closure and removal of late-emerging weeds by the supplementary hoe-weeding, all of which helped to sustain a weed-free condition throughout the crop life cycle. These results are similar to the findings of Peer et al. (2013) where pendimethalin integrated with hoe-weeding recorded a superior yield of soybean than hoe-weeding treatments. Also, a number of researches like Veeramani et al. (2001) and Osipitan et al. (2013) held similar views and reported higher yield with integrated weed management.

Despite the higher yield and revenue obtained with three hoe-weedings than herbicide treatments applied alone or supplemented by hoe-weeding in plots planted at 75- and 100-cm row spacings, the gross profit and benefit-cost ratio obtained were lower than those obtained with herbicide treatments applied alone or supplemented by hoe-weeding. This shows that the gain in yield and revenue from three hoe-weeded plots was nullified by the higher total cost of production as a result of accumulated labor which is usually expensive. Hence, the reduced benefit-cost ratio was obtained with three hoe-weedings. In all the three row spacings, pre-emergence application of herbicides (Probaben 400EC or butachlor 60EC each at 2.0 kg a.i/ha) consistently resulted in the highest cost-benefit ratio, and when supplemented by hoe-weeding at 6 WAS, the highest yield and gross profit were consistently obtained (Table 2). This study has shown that pre-emergence herbicides followed by supplementary hoe-weeding produced greater yield at less cost than the typical practice of hoe-weeding. Our findings of the cost-effectiveness of herbicides for weed management in soybean are in line with previous studies, in which researchers found that weed control with appropriate herbicides provided higher net benefits than manual hoe weeding (Khaliq et al., 2002; Suria et al., 2011). When the crops were planted at 50-cm or 75-cm row spacings, two hoe-weedings resulted in higher cost-benefit ratio than three hoe-weedings, however, with 100-cm row spacing, three hoe-weedings gave higher cost-benefit ratio than two hoe-weedings (Table 2). This further confirms that the benefit of the reduced number of hoe-weedings increases with a reduction in row spacing as a result of complementary weed control provided by the shading effect of crop canopy on weed at narrow- compared to wide-row spacing (Bhagirath et al., 2016).

Table 2. The breakdown of the economic analysis of weed management methods for soybean cultivation as affected by row spacing (data averaged for two trials).

Row spacing	Weed control methods	Seed and seed treatment	Land preparation	Planting	Weed control	Harvesting/ threshing	Total	Yield (kg/ha)	Total revenue	Gross profit	Benefit-cost ratio
50 cm	Probaben at 2.0 kg a.i/ha	91.4	77.1	128.6	46.4	128.6	472.1	1922.0	1647.4	1175.6	2.5
	Probaben at 2.0 kg a.i/ha fb shw	91.4	77.1	128.6	224.3	128.6	650.0	2484.2	2129.1	1479.3	2.3
	Butachlor at 2.0 kg a.i/ha	91.4	77.1	128.6	55.7	128.6	481.4	1981.3	1698.0	1217.5	2.5
	Butachlor at 2.0 kg a.i/ha fb shw	91.4	77.1	128.6	235.7	128.6	661.4	2301.3	1972.3	1311.6	2.0
	2 hoe-weedings at 6 and 9 WAS	91.4	77.1	128.6	368.6	128.6	794.3	1943.4	1665.4	871.0	1.1
	3 hoe-weedings at 3, 6 and 9 WAS	91.4	77.1	128.6	552.9	128.6	978.6	1947.8	1668.9	690.0	0.7
	Weedy check	91.4	77.1	128.6	0.0	128.6	425.7	980.0	840.0	414.3	1.0
75 cm	Probaben at 2.0 kg a.i/ha	73.1	77.1	85.7	46.4	85.7	368.1	1749.2	1499.1	1131.3	3.1
	Probaben at 2.0 kg a.i/ha fb shw	73.1	77.1	85.7	217.9	85.7	539.6	1999.3	1713.4	1174.4	2.2
	Butachlor at 2.0 kg a.i/ha	73.1	77.1	85.7	55.7	85.7	377.4	1792.4	1536.0	1159.4	3.1
	Butachlor at 2.0 kg a.i/ha fb shw	73.1	77.1	85.7	227.1	85.7	548.9	2013.2	1725.4	1177.5	2.1
	2 hoe-weedings at 6 and 9 WAS	73.1	77.1	85.7	342.9	85.7	664.6	1816.1	1556.6	892.0	1.3
	3 hoe-weedings at 3, 6 and 9 WAS	73.1	77.1	85.7	514.3	85.7	836.0	2155.4	1847.1	1011.1	1.2
	Weedy check	73.1	77.1	85.7	0.0	85.7	321.7	500.0	428.6	107.0	0.3
100 cm	Probaben at 2.0 kg a.i/ha	54.9	77.1	64.3	46.4	64.3	307.0	1513.3	1296.9	990.0	3.2
	Probaben at 2.0 kg a.i/ha fb shw	54.9	77.1	64.3	217.9	64.3	478.4	1810.4	1551.4	1073.0	2.2
	Butachlor at 2.0 kg a.i/ha	54.9	77.1	64.3	55.7	64.3	316.3	1495.2	1281.4	965.3	3.1
	Butachlor at 2.0 kg a.i/ha fb shw	54.9	77.1	64.3	227.1	64.3	487.7	1815.5	1555.7	1068.4	2.2
	2 hoe-weedings at 6 and 9 WAS	54.9	77.1	64.3	342.9	64.3	603.4	1582.4	1356.0	753.5	1.2
	3 hoe-weedings at 3, 6 and 9 WAS	54.9	77.1	64.3	514.3	64.3	774.9	2081.4	1783.7	1009.0	1.3
	Weedy check	54.9	77.1	64.3	0.0	64.3	260.6	288.6	246.9	-14.0	-0.1
	Lsd (5%)							149.0			

a.i – active ingredient, shw – supplementary hoe-weeding, WAS – weeks after sowing.

In terms of overall profitability, soybean planted at 50-cm row spacing and treated with the pre-emergence application of Probaben 400EC at 2.0 kg a.i ha^{-1} followed by supplementary hoe-weeding at 6 WAS gave the highest gross profit of $1479/ha. This was followed closely by soybean planted at 50-cm row spacing and treated with the pre-emergence application of butachlor 60EC at 2.0 kg a.i ha^{-1} followed by supplementary hoe-weeding at 6 WAS with a gross profit of $1311/ha. Due to severe weed pressure, planting soybean at 100-cm row spacing was not profitable without weeding. The economic analysis revealed that, when weeds were not controlled at 100-cm row spacing, a loss of $14/ha was incurred and the cost-benefit ratio was negative (- 0.1). On the other hand, however, no loss was incurred with the use of 50-cm and 75-cm row spacings, even in weedy plots, although it was more profitable to control weeds than allowing weeds on plots at these row spacings. Controlling weed resulted in 66–257 and 733–1000% higher profit than when the crops were left weedy in 50-cm and 75-cm rows, respectively. These results have corroborated earlier reports of Osipitan et al. (2018) that narrow-row spacing reduced economic losses caused by weed infestation and had the potential to increase per capita income as a result of increased yield.

Conclusion

The total variable cost of soybean cultivation was substantially influenced by row spacing and cost of weed control. Narrow-row spacing (50 cm) reduced weed biomass and increased the cost of production and grain yield with subsequent higher gross profit than intermediate- (75 cm) and wide-row (100 cm) spacing. Irrespective of the row spacing, two and three hoe-weedings resulted in higher cost of weed control than pre-emergence herbicide treatments applied alone or supplemented by hoe-weeding. Three hoe-weedings gave the highest yield and gross profit when the crops were planted at 100-cm row spacing. However, an increase in the number of hoe-weedings to two or three times at 50-cm and 75-cm row spaced plots did not guarantee maximum yield and gross profit, but rather increased the cost of weed control, particularly under narrow-row spacing (50 cm). When the crops were planted in narrow rows (50 cm), the highest net benefit could be achieved by using pre-emergence Probaben 400EC or butachlor 60EC each applied alone at 2.0 kg a.i ha^{-1}, and when supplemented by hoe-weeding at 6 WAS, the highest yield and gross profit were consistently obtained. Our study suggests that the use of pre-emergence herbicides supplemented by one hoe-weeding for weed management could help to reduce dependence on multiple hoe-weedings, reduce weed growth, and optimize yield as well as increase profitability and benefit-cost ratio especially under narrow-row spacing in soybean cultivation.

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Received: March 28, 2019
Accepted: July 23, 2019

EKONOMSKI EFEKTI MEĐUREDNOG RASTOJANJA I INTEGRALNOG SISTEMA SUZBIJANJA KOROVA U SOJI (*GLYCINE MAX* L.)

Olumide S. Daramola[1*], Olusegun R. Adeyemi[1], Joseph A. Adigun[1] i Christopher O. Adejuyigbe[2]

[1]Odsek za fiziologiju biljaka i proizvodnju useva, Poljoprivredni federalni univerzitet, Abeokuta
[2]Odsek za nauku o zemljištu, Poljoprivredni federalni univerzitet, Abeokuta

R e z i m e

Visoki troškovi uzgajanja i suzbijanja korova predstavljaju glavne ograničavajuće faktore za povećanje produktivnosti soje i neto prihoda. Poljski ogledi su sprovedeni 2016. i 2017. godine na Nastavno-istraživačkom dobru Poljoprivrednog federalnog univerziteta u Abeokuti da bi se ispitali ekonomski efekti različitih međurednih rastojanja i integralnog sistema suzbijanja korova u proizvodnji soje. Eksperiment je postavljen po potpuno slučajnom blok sistemu u tri ponavljanja, sa tri glavna tretmana koji predstavljaju različita međuredna rastojanja (50, 75 and 100 cm). Ovi tretmani su podeljeni na 7 podtretmana koji uključuju šest metoda suzbijanja korova i zakorovljenu kontrolu. Smanjenje međurednog rastojanja sa 100 cm na 75 cm, odnosno 50 cm dovelo je do značajnog smanjenja biomase korova. Osim toga, troškovi proizvodnje, prinos zrna i bruto dobit su povećani sa smanjenjem međurednog rastojanja sa 100 cm na 75 cm, odnosno 50 cm. Kada je soja posejana na međuredno rastojanje od 50 cm, primena 2 kg a.s./ha herbicida Probaben 400EC (metolahlor 20% w/v + prometrin 20% w/v) ili Butahlor 60 EC (butahlor) uz okopavanje 6 nedelja posle setve obezbedila je najveći prinos od 2301–2484 kg/ha i ukupni prihod od 2129–1972 $/ha. Suprotno tome, tri okopavanja su obezbedila najviši prinos od 2155–2081 kg/ha i ukupni prihod od 1848–1783 $/ha za useve gajene na međurednim rastojanjima od 75 i 100 cm. Uprkos većem prinosu i prihodu dobijenim sa tri okopavanja za tretmane sa međurednim rastojanjima od 75 i 100 cm, bruto dobit i odnos prihoda i troškova bili su niži nego za tretmane u kojima je primenjen samo herbicid ili je primena herbicida kombinovana sa okopavanjem. Kada je profitabilnost u pitanju, najveća bruto dobit od 1479 $/ha je postignuta kada je soja zasejana na međurednom rastojanju od 50 cm i tretirana sa 2 kg a.s./ha herbicida Probaben 400EC u kombinaciji sa okopavanjem. Dva ili tri okopavanja soje posejane na uskom (50 cm) međurednom rastojanju nisu garantovala najveći prinos, ali su prilično povećala troškove suzbijanja korova. Ovim istraživanjem se sugeriše da će se uskim međurednim rastojanjem (50 cm) i primenom herbicida pre nicanja smanjiti

[*]Autor za kontakt: e-mail: olumidedara01@gmail.com

broj okopavanja, pa time i visoki troškovi proizvodnje koji su neophodni za optimalni prinos, kao i da će se povećati profitabilnost proizvodnje soje.

Ključne reči: ekonomika, međuredno rastojanje, soja, integralni sistem suzbijanja korova, bruto dobit.

Primljeno: 28. marta 2019.
Odobreno: 23. jula 2019.