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Effect of Weed Management on Weeds and Grain Yield of Haricot Bean

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Abstract

Weeds are one of the major constraints limiting haricot bean productivity and production. Field experiments were conducted on the effect of weed managements on weeds and grain yield of haricot bean (Phaseolus Vulgaris L.) at Melkassa Agricultural Research Center from 2011 - 2013. The objective was to determine the effect of weed managements, varieties and their interaction on weeds and grain yield. The experiment was laid out split plot arrangement using randomized complete block design with three replications. Treatments were s-metolachlor at the rate of 0.96 kg ha^{-1}, glyphosate at the rate of 1.08 kg ha^{-1}, integration of each herbicide with hand-weeding at 45 days after sowing, twice hand-weeding at 25 and 45 day after sowing and un-weeded check. Nicandra physalodes, Xanthium strumarium and Argemone ochroleuca were the dominant weed species. Weed density and dry matter weight were significantly influenced by weed managements. The highest (129.50 m^{-2}) and the lowest (69.50 m^{-2}) weed density were recorded from weedy check and integration of s-metolachlor at the rate of 0.96 kg ha^{-1} and hand-weeding. Comparison of weed managements showed that the lowest (114.72 gm^{-2}) weed dry matter was recorded from application of s-metolachlor with hand-weeding at 45 days after sowing while the highest (349.50 gm^{-2}) weed dry matter was obtained from weedy check. The highest (67.17%) weed control efficiency was obtained from integrated use of s-metolachlor with supplementary hand-weeding. The effect of variety, weed managements and their interaction showed significant difference ($p<0.05$) on yield components and grain yield. The highest yield components and grain yield were obtained from s-metolachlorplus hand-weeding while the lowest grain yield was obtained from weedy check. The relationship between weed dry matter and grain yield showed significant negative correlation. Interaction effects of years, variety and managements showed non-significant ($p < 0.05$) difference for all parameters. The effect due to varieties and the interaction of variety and management did not show significant difference on weed density and dry matter though yield components and grain yield were significantly affected. This might be due to similar plant architecture or leaf canopy closure but difference in yielding potential of the test varieties. Hence, similar weed control practices can be recommended for both varieties.

Introduction

Haricot bean (*Phaseolus vulgaris* L.) is among the five most important food legumes of Ethiopia and is mainly grown at an intermediate altitude ranging from 1400 to 1800 m (Tilahun, 1998). It is the world's most important food legume for direct human consumption. Average per capita consumption of haricot bean in the main bean production areas is higher in Africa, estimated at 31.4 kg/year (Katungi *et al*., 2010). Being high in nutrient content and having commercial potential, haricot bean holds great promise for fighting hunger, increasing income and improving soil fertility (Katungi *et al*., 2010).

However, the growth in haricot bean productivity has been slow as a result of biotic and abiotic factors in which weeds are the major production constraints. Weeds cause significant yield reduction primarily by competing with crop for light, nutrients and space. Haricot bean yield losses of 35-90% have been reported at different part of the country due to weed competition (Rezene, 1985; Etagagnehu, 1987; Tilahun, 1998 and Meseret *et al*., 2008)

Cognizant of this, research and development efforts have been made for several years in the past and a number of weed management options have been recommended and disseminated among haricot bean producers. In spite of this effort made, crop husbandry is still poor with a significant number of farmers weeding once or not at all. Katungi *et al* (2009) reported that even though promotional effort to disseminate good management has been growing, the pulse crop has been poorly managed, especially in Ethiopia where some farmers do not even weed their haricot bean gardens. On the other hand, farmers of the dry land areas spent more time and energy on weed control than any other activities of crop production due to limited awareness on use of efficient weed management technologies. Thus, to ensure sustainable haricot bean productivity as well as production both for home and market consumption improved weed managements have to be widely practiced based on the variety response to the practices.

However, there is no or little information available on the varietal interaction to improved weed management. Therefore, the objective of this study was to determine the effect of weed management, variety and their interaction on weeds and grain yield of haricot bean.

Materials and Methods

Study Area

The experiment was conducted at Melkassa Agricultural Research Center during 2011, 2012 and 2013 cropping seasons. Melkassa Agricultural Research Center is located at $8^{0}24'$N and $39^{0}21'$E at an elevation of 1550 m. The area is characterized by high temperature throughout the year particularly in May, combined with high sunshine hours, low humidity, and general dry conditions except during very few wet months. It receives mean annual rain fall of 763 mm with erratic distribution with peaks occurring in July and August in a mono-modal pattern. The annual average minimum and maximum temperatures at the Centre are 13.8 ^{0}C, and 28.6 ^{0}C, respectively. The soil type of the experimental site is well drained silt clay loam soil largely developed from quaternary volcanic deposit parent material (Tefera *et al.*, 1996).

Experimental Procedures

The experiment was set up in split plot arrangement using a randomized complete block design in three replications. The varieties were assigned to main plots while the managements were allocated randomly to sub plots. Haricot bean varieties named as 'Awash-1' and 'Nasir' were used as test crop. The weed managements were s-metolachlor (applied pre-emergence of the weed and crop at the rate of 0.96 kg ha^{-1}), glyphosate (applied post-emergence of the weed at the rate of 1.08 kg ha^{-1}, combination of each herbicide with hand-weeding at 45 days after sowing, twice hand-weeding at 25 and 45 day after sowing (standard check) and un-weeded check. The area of each experimental plot was 4 m x2.4m (9.6 m^2). Glyphosate was applied as post-emergence onto the actively growing weed species 8 days prior to planting. However, s-metolachlor applied on to a well-prepared soil as pre-emergence for both weed and crop early after sowing. Hand-weeding was made in the assigned plots as per the treatment.

Data Collection and Analysis

Weed density and dry biomass were assessed at crop maturity from two 0.25 m^2 quadrat placed randomly in each plots. Within each quadrant weed species were identified. The collected weed fresh biomass was dried and weighed. Haricot bean grain yield harvested from the four central rows of each plot was converted to hectare. Data on weed density, weed biomass, weed control efficiency , pod per plant, seed per pod, hundred seed weight and grain yield were subjected to analysis of variance using SAS software and means were separated using the least significance difference at 5% probability level (SAS, 2004).Weed Control Efficiency (WCE) of treatments was calculated as:

$$WCE= \frac{DWC-DWT}{DWC} x100$$

Where, DWC was weed dry weight in weedy check, DWT weed dry weight in treated plot. The treatments are described as follows

- Awash-1 (Weedy check)
- Awash-1 + Twice hand-weeding at 25 & 45 days after sowing (standard check)
- Awash-1 + S-metolachlor at the rate of 0.96 kg ha^{-1}
- Awash-1 + Glyphosate at the rate of 1.08 kg ha^{-1}
- Awash-1 + S-metolachlor at the rate of 0.96 kg ha^{-1}+ hand-weeding at 45 days after sowing
- Awash-1 + Glyphosate at the rate of 1.08 kg ha^{-1}+ hand-weeding at 45 days after sowing
- Nasir (Weedy check)
- Nasir + Twice hand-weeding at 25 & 45 days after sowing (standard check)
- Nasir + S-metolachlor at the rate of 0.96 kg ha^{-1}
- Nasir + Glyphosate at the rate of 1.08 kg ha^{-1}
- Nasir + S-metolachlor at the rate of 0.96 kg ha^{-1}+ hand-weeding at 45 days after sowing
- Nasir + Glyphosate at the rate of 1.08 kg ha^{-1}+ hand-weeding at 45 days after sowing

Result and Discussion

Weed Species Composition

Eighteen weed species were recorded from the experimental fields (Table 1). Majority (greater than 80%) of them were broad leaf weed species. In all the three years *Nicandra physalodes, Xanthium strumarium and Argemoneo chroleuca* were the dominant weed species.

Table 1. Weed species and their average density (plants m^{-2}) recorded (Melkassa, 2011-2013)

Scientific name	Family name	Common name	Characteristics	Plant m^{-2}
Xanthium strumarium L.	Asteraceae	Cocklebur	Annual	7.0
Nicandra physalodes (L.) Gaertn.	Solanaceae	Apple of Peru	Annual	4.5
Guizotia scabra (Vis.) Chiov	Asteraceae	Sun flecks	Annual	12.0
Datura stramonium L.	Solanaceae	Moonflower	Annual	3.0
Galinsoga parviflora Cav.	Asteraceae	Gellant Solder	Annual	28.0
Argemone ochroleuca Sweet	Papaveraceae	Mexican poppy	Annual	11.0
Eluesine indica (L.)Gaertner	Poaceae	Goose grass	Annual	5.0
Cyperus rotundus L.	Cyperaceae	Purple nutsedge	Perennial	4.0
Cyperus esculentus L.	Cyperaceae	Yellow nutsedge	Perennial	8.0
Chenopodium album L.	Chenopodiaceae	Lamb's-quarters	Annual	3.0
Amaranthus hybridus L.	Amarantaceae	Pig Weed	Annual	5.0
Polygonumne palense Meisner	Polygonaceae	Snake weed	Annual	3.0
Bidens pilosa L.	Asteraceae	Blackjack	Annual	13.0
Leucas martinicensis (Jacq)	Lamiaceae	Whitewort	Annual	3.0
Anagallis arvensis L.	Primulaceae	Red chickweed	Annual	3.5
Setaria verticillata (L.) P.Beav	Poaceae	Bristly foxtail	Annual	7.0
Commelina benghalensis (L.)	Commelinaceae	Tropical spiderwort	Annual	2.5
Parthenium hysterophorus (L.)	Asteraceae	Congress weed	Annual	7.0

Effect of Weed Managements on Weed Dry Matter, Density and Control Efficiency

A significant difference in weed dry matter was observed among weed managements. The lowest weed dry matter weight was recorded from s-metolachlor plus hand-weeding at 45 days after sowing treated plot followed by twice hand-weeding at 25 and 45 days after sowing and glyphosate application with supplementary hand-weeding. This suggests that the removal of lately emerged weed species by hand-weeding contributed to the low weed dry matter. On other hand the maximum weed dry matter was obtained from weedy check followed by glyphosate. Weed dry matter decreased further when herbicides are integrated with hand-weeding. This work is in agreement with the finding of Singh and Sekhon (2013) who suggested that effective weed control has been obtained with integrated use of herbicides and hand-weeding.

Table 2. Effect of weed management and variety on weed density, weed dry matter and weed control efficiency.

Treatments	Density (no m^{-2})	Dry matter (g m^{-2})	WCE (%)
Variety (V)			
Awash-1	97.67[a]	209.92[a]	41.83[a]
Nassir	97.44[a]	208.06[a]	42.11[a]
Management (MP)			
Weedy check	129.50[a]	349.50[a]	0.00[e]
Twice hand-weeding at 25 & 45 DAS (standard check)	70.50[e]	118.57[d]	67.78[a]
S-metolachlor at the rate of 0.96 kg ha^{-1}	119.11[c]	215.50[c]	34.72[c]
Glyphosate at the rate of 1.08 kg ha^{-1}	123.28[b]	328.39[b]	26.44[d]
S-metolachlor at the rate of 0.96 kg ha^{-1}+ hand-weeding at 45 DAS	69.50[e]	114.72[d]	69.94[a]
Glyphosate at the rate of 1.08 kg ha^{-1}+ hand-weeding at 45 DAS	73.44[d]	127.27[d]	64.94[b]
V*MP	ns	ns	ns
Mean	97.56	208.99	41.97
CV (%)	2.26	10.21	12.69

**DAS-days after sowing*

The weed densities were significantly influenced by weed managements during all season. Thus, effect of different weed managements on weed density was significant at 5% probability. The highest weed density (129.50 plants m^{-2}) was recorded from weedy check followed by the application of glyphosate(123.28/m^2); whereas the lowest weed density (69.50no/m^2)was recorded from the integration of s-metolachlor with hand-weeding followed by twice hand-weeding at 25 and 45 days after sowing (70.50 m^{-2}) and glyphosate application plus supplementary hand-weeding (73.44 m^{-2}). The lowest weed density in application of chemicals with hand-weeding is due to the fact that s-metolachlor and glyphosate control early weed growth while hand-weeding reduces late emerging weeds during crop growth cycle. S-metolachlor inhibits cell division by interfering with biosynthesis of long chain fatty acids while glyphosate inhibits the shikimic acid pathway, causing a deficit in aromatic amino acids. As these amino acids are needed for plant growth and maintenance, the application of glyphosate may quickly result in plant death. Furthermore, supplementary hand-weeding also highly contribute to the effectiveness of herbicides by removing weeds escaping application of chemicals and lately emerging weeds.

The effects due to managements were significant on weed dry matter and density. However, the effect due to variety showed non-significant difference ($p< 0.05$) on weed dry matter and density. Among the managements, s-metolachlor with hand-weeding had the lowest weed dry matter, though twice hand-weeding at 25 and 45 days after sowing, glyphosate with hand-weeding and s-metolachlor alone were not statistically different. There was a significant difference among s-metolachlor with hand-weeding and s-metolachlor alone. Hence, using herbicides only is not recommended. Rather, supplementary herbicide with hand-weeding is very important to control escaping plus lately emerging weeds and minimize the weed problem (Table 2). Similar to weed density and weed dry matter, maximum weed control efficiency (69.94%) was obtained from s-metolachlor plus hand-weeding followed by twice hand-weeding at 25 and 45 days after sowing and supplementary hand-weeding.

Effect of Weed Management on Haricot Bean Grain Yield and Yield Components

Analysis of variance showed that a significant difference in pod per plant, seed per pod, hundred seed weight and grain yield were observed among different weed management and variety. The highest grain yield was obtained from the integration of s-metolachlor and hand-weeding followed by twice hand-weeding at 25 and 45 days after sowing, s-metolachlor and the integration of glyphosate and hand-weeding; whereas lower grain yield was obtained from weedy check and glyphosate. However, the grain yield in all the treatments was statistically different from each other.

Although herbicides alone is not effective without supplementary hand-weeding, application of only s-metolachlor showed significantly higher grain yield than glyphosate with supplementary hand-weeding weeding in both varieties (Table 3). This might be due to the herbicides mode of action and time of application, i.e., s-metolachlor applied on to well-prepared soil controlled weeds effectively by inhibiting weed emergence when applied at pre-emergence of the crop and weeds. Whereas the application of glyphosate was made onto an actively growing weeds before planting of the crop. As a result weeds emerged with crop can easily compete with crop and cause significant yield reduction unless it is removed timely. This finding is in agreement with the work of Tenaw Workayehu and Mathias Mekuria (1998) who reported that pre-emergence herbicides were more beneficial and have resulted in vigorous growth and better yield of haricot bean. Similarly, Singh and Sekhon (2013) also reported that integration of herbicides and hand-weeding provided the high weed control efficiency and produced the highest grain yield. The findings of the study were in coherence with that of Waktole *et al*. (2013) who reported that application of s-metolachlor superimposed with one hand-weeding resulted in the highest grain yield.

Interaction effects of years, variety and managements showed non-significant ($p < 0.05$) difference for all parameters (weed density, weed dry matter, weed control efficiency, grain yield, pod per plant, seed per pod and hundred seed weight (Table 3).The interaction effect of variety and weed managements showed significant difference ($p<0.05$) inpod per plant, seed per pod and grain yield. Interaction of variety and un-weeded treatment showed non-significant difference ($p<0.05$) in all parameters except seed per pod. Interaction of variety and twice hand-weeding also showed non-significant difference on seed per pod, hundred seed weight (Table 3).

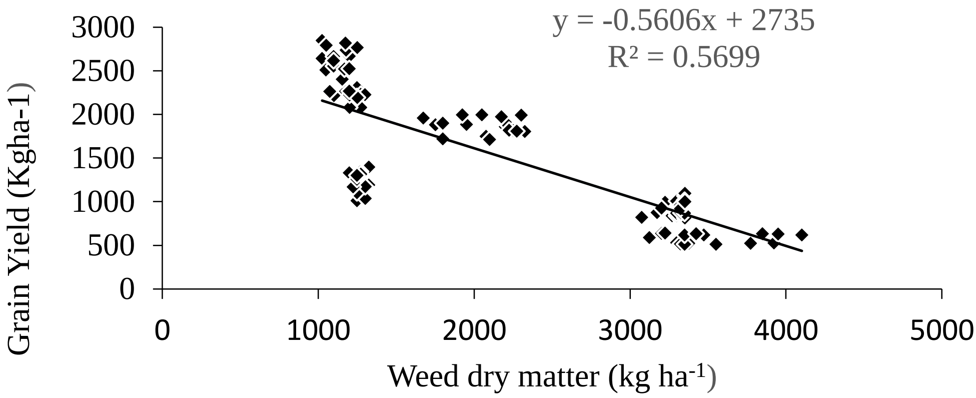

Figure 1. Relationship between weed dry matter at harvest and haricot bean grain yield

The analysis of the relationship between weed dry matter and haricot bean grain yield demonstrated as significant correlation. Figure 1 shows that there is a negative correlation between grain yields and weed dry matter. That means that as grain yield increases, the weed dry matter declines, and vice versa. Thus emphasis should be given to control weeds for obtaining high grain yield. However, comparison of s-metolachlor and glyphosate+ hand-weeding at 45 days after sowing is not agree with the inverse relationship of dry matter and grain yield. This is due to the fact that crops are highly affected by weed infestation at early stage.

In general, the effect due to variety and the interaction of variety by management did not show significant difference on weed density and dry matter; while the grain yield was significantly affected by variety, management and their interaction. This might be due to the similar plant architecture or leaf canopy closure of the varieties and the difference in varieties yielding potential. This implies that the two varieties did not show significant difference to different weed management in different ways. Hence instead of evaluating weed management independently, similar practices can be recommended for both varieties.

Table3. Mean grain yield and yield components as influenced by the interaction of management and haricot bean varieties

Management	Grain yield (kg ha^{-1})		Pod/plant		Seed/pod		Hundred seed weight (g)	
	Awash-1	Nasir	Awash-1	Nasir	Awash-1	Nasir	Awash-1	Nasir
Weedy check	532.31^{h}	628.32^{h}	6.24g^{f}	6.87^{f}	532.31^{h}	628.32^{h}	6.24g^{f}	6.87^{f}
Twice hand-weeding at 25 & 45 DAS (standard check)	2173.79^{c}	2575.35^{b}	9.56^{c}	11.06^{b}	2173.79^{c}	2575.35^{b}	9.56^{c}	11.06^{b}
S-metolachlor at the rate of 0.96 kg ha^{-1}	1828.39^{d}	1920.92^{d}	9.41^{c}	10.97^{b}	1828.39^{d}	1920.92^{d}	9.41^{c}	10.97^{b}
Glyphosate at the rate of 1.08 kg ha^{-1}	851.27^{g}	997.17^{f}	6.81^{f}	6.60g^{f}	851.27^{g}	997.17^{f}	6.81^{f}	6.60g^{f}
S-metolachlor at the rate of 0.96 kg ha^{-1}+ hand-weeding at 45 DAS	2244.53^{c}	2715.23^{a}	10.84^{b}	14.05^{a}	2244.53^{c}	2715.23^{a}	10.84^{b}	14.05^{a}
Glyphosate at the rate of 1.08 kg ha^{-1}+ hand-weeding at 45 DAS	1002.71^{f}	1291.41^{e}	7.53^{e}	8.63^{d}	1002.71^{f}	1291.41^{e}	7.53^{e}	8.63^{d}
Mean	1438.83^{B}	1688.06^{A}	8.40^{B}	9.70^{A}	4.01^{B}	4.55^{A}	17.33^{B}	17.88^{A}

DAS- days after sowing; capital letter 'A' And 'B' indicated mean difference between varieties

Table 4. Mean square of grain yield and yield components of haricot bean variety, weed density, weeds dry matter and weed control efficiency

Source of variation	Degree of Freedom	Mean of squares of weeds and yield components						
		Weed density (No. m^{-2})	Weed dry matter (g m^{-2})	WCE (%)	Grain yield (kg ha^{-1})	Seed (pod^{-1})	HSW (g)	Pod (plant^{-1})
Year (Y)	2	72.75^{ns}	1796.24^{ns}	84.71^{ns}	17317.73^{ns}	0.08^{ns}	0.27^{ns}	0.78^{ns}
Variety (V)	1	1.33^{ns}	93.58^{ns}	677.00*	1677155.9*	7.97*	8.44*	45.34*
Y*V	2	7.19^{ns}	614.88^{ns}	68.20^{ns}	12847.08^{ns}	0.03^{ns}	0.66^{ns}	1.04^{ns}
Managements (MP)	5	15289.87*	208017.76*	11984.41*	11315359.74*	17.45*	142.14*	97.48*
Y*MP	10	7.92^{ns}	509.42^{ns}	33.38^{ns}	14259.87^{ns}	0.13^{ns}	0.20^{ns}	0.10^{ns}
V*MP	5	5.07^{ns}	734.17^{ns}	360.88^{ns}	119265.93*	0.89*	0.82^{ns}	5.88*
Y*VAR*MP	10	5.43^{ns}	437.00^{ns}	103.72^{ns}	15607.34^{ns}	0.23^{ns}	0.13^{ns}	0.28^{ns}
Pooled Error	71	4.65	460.74	87.30	12669.69	0.13	0.49	0.26
R-Square		0.99	0.97	0.91	0.98	0.92	0.96	0.97
CV (%)		2.21	10.27	21.82	7.20	8.34	3.97	5.60

*CV-Coefficient of Variation; * Significant at 5% probability level, ns=non- significant difference*

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