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Effect of Different Common Bean (*Phaseolus vulgaris* L.) Planting Densities on Weed Control in Intercropping System with Roselle (*Hibiscus sabdariffa* L.) Varieties at Hawassa, Southern Ethiopia

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ABSTRACT

The experiment was conducted to determine best common bean planting density for better weed control in intercropping with two roselle varieties at Hawassa, southern Ethiopia. It was arranged in a 2x4 factorial with RCBD design in three replications. The treatment of the experiment was 10: (sole cropping of the roselle varieties, and combination of 25%, 50%, 75% and 100% common bean planting densities with the two roselle varieties). Visual weed infestation rating (scale1-6), weed density and dry aboveground weed biomass were collected used for analysis and all were subjected to analysis of variance using SAS software version 9.3. Differences between means were assessed using Duncan`s Multiple Range Test at 5% probability level. Results of the experiment showed that the interaction between the main factors (roselle variety and common bean planting density) were nonsignificant for all parameters. Common bean planting density and cropping system significantly affected weed infestation. The highest values for visual estimate weed ground coverage, weed density, and weed dry biomass were recorded for 25% common bean planting density (2, 15.43 plant/m^2, and 13.34g/m^2 respectively) and for sole roselle cropping (2.5, 17.21 plant/m^2, and 15.61g/m^2 respectively). Increases in common bean planting densities showed decreasing trends in weed infestation. Therefore, intercropping roselle with 100% common bean planting density was recommended for better weed control for growers in the study areas as well as similar agroecologies.

Keywords: Intercropping, weed infestation,

INTRODUCTION

Weed is one of the major crop production constraints in southern part of Ethiopia. Through competing for growth resources, such as nutrient, moisture and sun light, weeds can affect quantity and quality of crop yield (Memon et al., 2013). Besides, weeds favor disease and insect pests that can further affect crop production. Growers have been used various ways to decrease the influence of weeds. The most common and repetitive methods that have been used to control weeds include application of herbicide and hand weeding. However, in addition to increase in cost of production and development of herbicide resistance, application of herbicide has detrimental effects on environmental resources such as soil, water and beneficial insects (Santos et al., 2014). Therefore, in order to reduce the negative effects of weeds as well as the side effects of herbicides applications, studies have been indicated the importance of agronomic practices, like intercropping, for weed suppression (Shah et at., 2011; Khan et al., 2013). The advantages of intercropping system on weed control as compared to monocropping might be due to efficient intercrops competition for growth resources and also due to allelopathic effects on weeds (Gomes et al., 2007). The reduction of weeds in a cropping system lowers the disease development opportunities and insect pests damage, that otherwise favored by the host weeds. Scholars indicated that proper crop selection, their temporal and spatial arrangements and management practices affected effectiveness of intercropping on weed control (Shah et at., 2011). It was also stated that, growing legumes in intercropping have reduced weeds infestation (Santos et al., 2014).

Common bean is one of the widely produced legumes crops in southern parts of Ethiopia for local and export markets contributing to foreign exchange earnings (Temesgen et al., 2015). It can be produced either in intercropping for yield, economic advantages and weeds suppression. However, no study showed intercropping performances of roselle and common bean on weeds suppression in Ethiopia. Hence, for a better intercropping performances for weeds suppression, appropriate proportion of common bean planting density should be identified. Thus, this experiment was initiated with objective to determine appropriate common bean planting density for better weeds control in intercropping with roselle varieties at Hawassa, southern Ethiopia.

MATERIAL AND METHODS

Site Descriptions: The experiment was conducted during 2017/2018 cropping season at Hawassa southern Ethiopia. It is located at $7^{0}05'$ North latitude, $39^{0}29'$ East longitude and at an altitude of 1652 m a.s.l. The area receives a bimodal rainfall with short and long rainy seasons from March to April and June to August, respectively and the average annual precipitation ranges from 1000 to 1800 mm. The minimum, mean and maximum temperatures of the area are 13, 20 and 27 °C, respectively. The soil textural class of the area is sandy loam with a pH of 7.2 (Dessie and Kleman, 2007). The agro-climatic condition of the area is warm sub-humid in which both food and cash crops are grown. Some of the common crops in the area include enset, maize, coffee, khat, banana, sugarcane and common bean. Maize and enset production for food as well as enset-coffee agro forestry farming system are largely practiced in the area. Common bean is commonly intercropped with other crops in the area.

Design and Treatments: The experiment was arranged in a 2x4 factorial with RCBD design. The experimental materials for the intercropping study were two roselle varieties (WG-Hibiscus-Sudan and WG-Hibiscus-Jamaica) and a common bean variety (Ibbado). The treatments of the experiment include:

1. Sole WG-Hibiscus-Sudan,
2. Sole WG-Hibiscus-Jamaica,
3. WG-Hibiscus-Sudan with 100% common bean planting density,

4. WG-Hibiscus-Sudan with 75% common bean planting density,
5. WG-Hibiscus-Sudan with 50% common bean planting density,
6. WG-Hibiscus-Sudan with 25% common bean planting density,
7. WG-Hibiscus-Jamaica with 100% common bean planting density,
8. WG-Hibiscus-Jamaica with 75% common bean planting density,
9. WG-Hibiscus-Jamaica with 50% common bean planting density and
10. WG-Hibiscus-Jamaica with 25% common bean planting density.

Management practices: The total experimental area was 538.72 m^2 (14.8m x 36.4m). Six rows of roselle were maintained in each plot, with a spacing of 60 cm between rows and 30 cm between plants in a row, which resulted in 48 and 55,555 plants per experimental plot and per hectare have been used, respectively. Nine rows of common bean were maintained per plot and for sole and 100% common bean planting density, 40 cm spacing between rows and 10 cm between plants within a row were used. The different common bean densities (100%, 75%, 50% and 25%) were obtained by varying spacing between plants with in a row (i.e., 10, 13, 20 and 40 cm for 100%, 75%, 50% and 25% common bean planting densities, respectively). Roselle and common bean were sown in separate rows, where common bean was seeded 30 days after roselle. Irrigation was applied as required by observing soil moisture status and plants responses to moisture stress in the field. Hand weeding was done twice following each weed data collection. Neither fertilizer nor chemical pesticide was applied during the experiment.

Data collection: Visual rating of weed ground coverage, weed density, and weed aboveground biomass weight were recorded and analyzed to evaluate the effect of different common bean planting densities on weed control in intercropping with roselle varieties. Estimation of visual rating of weed infestation was done for each plot using 1-6 scale, where 1 = 0-5% weed cover, 2 = 6-25% weed cover, 3 = 26-50% weed cover, 4 = 51-75% weed cover, 5 = 76-95% weed cover and 6 = 96-100% weed cover following the method developed by Subramanian et al. (1991) as cited by Orluchukwu and Udensi (2013). This was done twice during the experimental period (first weeding was done at 30 days after common bean planting and second weeding was done 30 days after the first weeding) and the average values were used for analysis. Visual weed infestation rating was done just before weeding the experimental plots.

Weed density (count/m^2) was also estimated twice during the experimental period, immediately following visual rating of weed infestation, by counting plants of each weed species observed in the net area of each plot and by converting the observed total number of weeds per net area of each plot to m^2. The average values of the two measurements per plot were calculated and converted into weed density per m^2. Following weed density estimation, weeds in each net plot area were cut at ground level, oven drying at 70 °C until constant weight achieved (Prasad et al., 2015) and weighed by using digital balance (model YP20002) to record aboveground weed biomass weight. Finally, the dry weed biomass values were converted to m^2 for analysis.

Data analysis: All data collected were subjected to analysis of variance (ANOVA) using SAS software version 9.3. Whenever the ANOVA indicated the presence of significant variations between treatments, mean separation was done using Duncan`s Multiple Range Test at 5% probability level (CR (0.05)**)** to indicate the minimum difference between mean values under comparison for the variation to be significant or not.

RESULT AND DISCUSION

Table1.Analysis of variance for visual rating of weed infestation, weed density, and aboveground biomass as affected by roselle variety, common bean planting density, and cropping system at Hawassa during 2017/2018

Mean squares

Source	DF	Visual weed infestation rating (scale1-6)	Weed density (plant/m^2)	Aboveground dry weed biomass (g/m^2)
Rep	2	0.66**	77.73 **	59.17 *
Var	1	0.26 ^{NS}	17.29 ^{NS}	33.56 ^{NS}
PD	3	0.70 **	93.70 **	42.20*
Var*PD	3	0.09^{NS}	19.9 ^{NS}	1.45^{NS}
Error	14	0.08	11.87	12.35
CV		18.64	36.19	34.82
Cropping system				
Rep	2	0.70 *	127.33*	55.15*
CS	1	4.22***	283.64**	155.21**
Error	2	0.18	26.40	15.95
CV		24.27	46.47	36.10

NS=not significant; *, **, and *** significant at P≤0.05, P≤0.01 and P≤0.001 probability levels respectively; Rep= Replication; DF =Degree of freedom; Var =Variety; PD = Planting density; CV= coefficient of variance; CS = Cropping syste

Visual weed infestation rating (scale 1-6):

The effect of roselle variety and the interaction of main factors variety and common bean planting density were nonsignificant to affect the visual weed infestation rating (P > 0.05)**,** while it was significantly affected by common bean planting density (P ≤ 0.01) and cropping system (P ≤ 0.001) (Table1)**.** A mixture of common bean with 25% planting density resulted in significantly higher scale value for weed infestation (2.0) compared to other planting densities (Table 2). The higher visual scale value for weed infestation at lower common bean planting density might be due to availability of free spaces and resources, which favored the growth of weeds. Similarly, significant higher values of visual weed infestation rating was recorded for sole cropping (2.5) than for intercropping (1.56) (Table 2). Higher free spaces and availability of more light in the sole cropping system due to lower canopy closure might have favored weed growth compared to the case in the intercropping system. It is also clear that, higher density of different crops in the intercropping system competes for resources and, thereby, reduces weed germination and growth more than in sole cropping. Hence, weed germination and growth might be reduced when roselle grown in combination with common bean as compared to roselle sole cropping.

Weed density (count per m^2)

Weed species density was recorded by counting number of each weeds per net plot area of each experimental plot and the values were converted to m^2 for analysis. A total of 15 weed species were identified, among which broad leaved weeds were dominant (73%) followed by grassy weeds (20%) and sedges (7%) (Table 3). It was observed that both interaction of the main factors and roselle variety did not have significant effect on weed density (P > 0.05), however, as indicated in table 1 below, it was significantly (p ≤ 0.01) influenced by common bean planting density and cropping system. Significant lower weed density (7.19 count per m^2) was observed for intercropping roselle with 100% common bean planting density, while higher value (15.43 count per m^2) was recorded for intercropping roselle with lower, 25%, common bean planting density (Table 2). This might be due to availability of more free space that favors weed germination and growth than the closely populated crops. Besides, weeds might got more light at distantly populated crops due to lower canopy closure and became competitor in field. Hence, reduction in weed density at higher common bean planting density in the present study could be due to limitation of resources, like space and light. Besides, the lower weed density in intercropping as compared to roselle sole cropping might be due to inclusion of component crop (common bean), which might enhanced the intercrops competitiveness for growth resources, thereby increasing resource utilization. This was similar with the report of Odhiambo and Ariga (2001), which indicated that high populations of bean intercropped with maize reduced striga weed. Besides, Prasad et al. (2015) have reported significant reduction in weed population for intercropping maize with cowpea than for sole maize. Furthermore, reports showed the positive contributions of cultivating crops in association in reducing weed density, like the case of wheat-pea intercropping (Khan et al., 2013) and maize-bean intercropping (Chipomho et al., 2015).

Table2: Mean values of visual weed infestation rating (VWIR), weed density (WD), and aboveground dry weed biomass (DWB) as affected by roselle varieties, common bean planting densities and cropping systems.

Treatment	VWIR (scale1-6)	WD (count / m^2)	WDB (g/m^2)
Roselle Variety			
Hibiscus-Jamaica	1.67	8.67	8.91
Hibiscus-Sudan	1.46	10.37	11.27
CR(0.05)	NS	NS	NS
Common Bean Planting Density			
100%	1.17^{c}	7.19^{b}	7.47^{b}
75%	1.50^{bc}	7.89^{b}	8.37^{b}
50%	1.58^{b}	7.56^{b}	11.19^{ab}
25%	2.00^{a}	15.43^{a}	13.34^{a}
CR(0.05)	0.36	4.27	4.35
CV	18.64	36.19	34.82
Cropping System			
Sole cropping	2.5^{a}	17.21^{a}	15.61^{a}
Intercropping	1.56^{b}	9.52^{b}	9.92^{b}
CR(0.05)	0.40	4.84	3.76
CV	24.27	46.47	36.10
Variety*Planting Density	NS	NS	NS

Note: NS=not significant; CV=Coefficient of variance; CR= Critical range; Means in a column followed by the same letters are not significantly different at P≤5%.

Aboveground weed biomass weight (gm^2)

Similar to the values for weed infestation and weed density, interaction of main factors as well as roselle variety did not affect aboveground weed biomass ($P > 0.05$), but it was significantly affected by common bean planting densities ($P \leq 0.05$) and cropping systems ($p \leq 0.01$) (Table1). The higher aboveground dry weed biomass (13.34 g/m^2) was resulted from intercropping roselle with 25% common bean planting density and the lowest value (7.47 g/m^2) was obtained from intercropping with 100% common bean planting density (Table2). This could be due to increases in competition for space and growth resources suppressing weed germination and growth as the planting density increased. The role of common bean in weed suppression when intercropped with roselle was clearly reflected by the significantly higher weed biomass yield obtained from sole cropped plots (15.61 g/m^2) compared to the lowest value for intercropping (9.92 g/m^2) (Table2). This might be due to effectiveness of intercrops in resource utilization, leaving smaller amounts for weeds growth compared to sole cropping, and it could also be through allelopathic effects of the intercrops on weeds (Yadollahi et al., 2014). Similarly, Orluchukwu and Udensi (2013) have reported significantly higher weed biomass for sole cropping of okra than when intercropped with maize and pepper.

Table 3. Weeds species and their relative density in roselle-common bean intercropping at Hawassa during 2017/2018 cropping season

Number	Weed species	Weed density (count/m^2)	Relative density (%)
1	Portulaca oleracea	4.76	24.84
2	Cyprus spp	3.86	20.13
3	Conyza canadensis	2.06	10.74
4	Datura stramonium	1.49	7.77
5	Digitaria abyssinica	1.27	6.61
6	Guizocia spp	0.92	4.82
7	Cynodon dactylon	0.87	4.53
8	Bidens pilosa	0.71	3.71
9	Galinsoga parviflora	0.69	3.60
10	Sonchus spp	0.65	3.38
11	Tagetus minuta	0.58	3.03
12	Snowdenia polystachya	0.39	2.03
13	Oxalis latifolia	0.36	1.88
14	Chenopodium spp	0.33	1.72
15	Amaranthus spp	0.23	1.20

CONCLUSION

Form the present findings, there was no variation between two roselle varieties (WG-Hibiscus-Sudan and WG-Hibiscus-Jamaica) in weed control. However, weed suppression was observed under intercropping these two varieties with common bean as compared to sole cropping of the varieties. Increase in planting densities of common bean from 25% to 100% resulted in reduction in weed infestation, as lower values for visual weed infestation rating, weed density, and aboveground biomass weight were obtained at 100% common bean planting density. Therefore, it is reasonable to suggest combinations of common bean at 100% planting density with roselle for better weed control for roselle production. But, the experiment has to be repeated under rainfed condition at different locations to come up with a more reliable weed control result.

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