Seed Yield and Quality of *Desmodium uncinatum (Jacq.) DC.* as Affected by Method and Time of Harvesting Seed at Wondo-Genet

Tekalegn Yirgu[1*], Solomon Mengistu[2], Fekede Feyissa[2], Getnet Assefa[3] and Edao Shanku[1]
[1] Wondogenet Agricultural Research Center, P.O.Box, 198, Shashemene, Ethiopia
[2] Holetta Agricultural Research Center, P.O.Box, 31, Holetta, Ethiopia
[3]Ethiopian Institute of Agricultural Research, P.O.Box, 2003, Addis Ababa, Ethiopia
*Corresponding author: tekalegney@gmail.com

ABSTRACT

A three year experiment was conducted at Wondo-Genet Agricultural Research Center to determine the appropriate time and efficient method of seed harvesting to produce large quantity of better quality Desmodium uncinatum (Jacq.) DC seed. The experiment was laid out in factorial combinations of Randomized Complete Block Design with four replications. The first harvest was made when the early pods started to disintegrate; and the second, third and fourth harvests were made one week, two weeks and three weeks after the first harvest, respectively. The harvesting methods used include direct mowing of the whole sward by sickle, hand picking of matured seed pods and sweeping of shattered seed pods from the ground. The results revealed that seed yield of D. uncinatum (Jacq.) DC. was significantly (P<0.001) affected by harvesting methods. However, there was no significant (P>0.05) interaction effects between harvesting method and time on seed yield. On average, the highest seed yield (281.9±11.8 kg ha^{-1}) was obtained in the hand picking method, while the lowest (27.2±11.8 kg ha^{-1}) was obtained from the sweeping method. On the other hand, the sweeping method resulted in higher 1000-seed weight (8.2±0.4) than the hand picking method (6.3±0.4) (P<0.01). Harvesting method and time did not have significant effect on germination percentage, number of inflorescences per meter square, number of spikelet per raceme and plant height (P>0.05). Thus it can be concluded that harvesting by hand picking is promising for producing large quantity seed from D. uncinatum (Jacq.) DC. Moreover, D. uncinatum (Jacq.) DC. seeds should be harvested within one week time following the beginning of fragmentation of the early pods.

Key words: *Desmodium uncinatum, harvesting method, harvesting time, seed yield*

INTRODUCTION

The major feed resources for livestock in tropics are mainly native pasture and crop residues which are poor in nutrient supply to keep animals at productive stage (Alemayehu Mengistu and Sissay Amare, 2003; Alemu Yami, 2016). In crop-livestock mixed farming systems of such regions, feed is one of the major limitations for livestock productivity (Berhanu Gebremedhin, 2007; Getahun *et al.*, 2008). As a result, livestock perform below their potential and suffer feed shortage at all levels (Alemu Yami, 2016). Therefore, it is necessary to evaluate and incorporate alternative high yielding and better quality forage seeds which can mitigate the prevailing forage seed related problems which in turn help to unlock the potential of farm animals via supply of better quality feeds. Inadequate availability of planting material in terms of both amount and diversity, and low level of experience and support to forage seed production are the major barriers to the progress of improved forage development in the country (Alemu Yami, 2016). For example by 2020, the small and medium specialized dairy sectors of Ethiopia will require an estimated 2520 tons of forage seeds per year (Shapiro *et al.*, 2015).

The sticky nature and presence of large amounts of vegetative material of Desmodium seed pods, harvesting even using modern harvesters has been considered to be a problem (English, 1988).

The choice of an efficient harvesting method depends on species to be harvested, size of the area, and availability and relative costs of labor and machinery. Some forage crops have indeterminate growth habit which has a negative effect on seed quality unless the seeds are harvested at optimum harvesting stage (Getnet Assefa *et al.,* 2012). The choice of harvesting time is a complicated decision for tropical pasture seed crops due to presence of some immature seeds. Days after inflorescence emergence were the chosen parameter to determine optimum harvesting time of forage seeds. It indicates when harvesting is likely to occur after inflorescence emergence. Desmodium seed yield is the product of inflorescence density, the number of floral nodes differentiated on each raceme, the number of seeds formed and recovered from each node, and the weight of individual seed formed (Nicholls *et al.,* 1973).

Desmodium has an outstanding performance across a wide range of environments (Roder *et al.,* 2002). Push-pull strategy requires an adequate amount of Desmodium seed production and distribution system in order to avail the seed for smallholder farmers (Khan *et al.,* 2014). However, the seed could not be widely used as it is not produced in adequate quantities and hence unavailable in the market. Despite close to half a century old research on forage crops in Ethiopia, research endeavors have been generally scanty in the areas of forage seed. As a result, very limited information is available on the appropriate agronomic management practices to be followed by forage seed producers for producing high quantity and better quality forage seeds. Therefore, this study was conducted to determine the appropriate time and efficient method of seed harvesting for *Desmodium uncinatum (Jacq.) DC.* under Wondogenet condition, Southern Ethiopia.

MATERIALS AND METHODS

Description of the Study Area

The study was conducted at the experimental field of Wondogenet Agricultural Research Center, which is located at 07°19' North latitude, 38°38' East longitude, with an altitude of 1876 meter above sea level. The area receives mean annual rain fall of 1000 mm with minimum and maximum temperature of 12.02 and 26.72°c, respectively. The texture of the soil was sandy clay loam (Notisol) with pH of 6.4 (Beemnet Kassahun *et al.,* 2015).

Treatments and Design

The experiment was laid-out in Randomized Complete Block Design with factorial arrangement of treatments in four replications. Twelve treatment combinations were used (Table 1). The seed was sown during the beginning of the main rain using 30 cm row spacing and a recommended seeding rate of 5 kg per hectare (Skerman *et al.,* 1988; ILRI, 2013). Harvesting time and harvesting method were the first and second factors, respectively. Factor one had four levels of harvesting time (the first harvest was made when the early pods start to disintegrate; and the second, third and fourth harvests were made one, two and three weeks after the first harvest, respectively). Factor two included three levels of harvesting methods (1= direct mowing of the whole sward by sickle; 2= selective stripping or hand picking of matured seedpods and 3= sweeping shattered seed pods on the ground). Mowing is the method of seed harvesting by cutting the entire stem with sickle and threshing while hand picking refers to stripping the seed from the inflorescence by running a hand from the base of the inflorescence upwards. Sweeping is disposing of the seed pods to shatter and then collect the seed

from the ground. The three harvesting methods were selected based on nature of hairy seed pods, which adhere to clothing and size of the seed. The treatment combinations were randomly and independently assigned to each block.

Table 1.Treatment combinations

Treatment No.	Harvesting Time (HT)	Harvesting Method (HM)	Treatment combinations
1	HT1	MW	HT1MW
2	HT1	PK	HT1PK
3	HT1	SW	HT1SW
4	HT2	MW	HT2MW
5	HT2	PK	HT2PK
6	HT2	SW	HT2SW
7	HT3	MW	HT3MW
8	HT3	PK	HT3PK
9	HT3	SW	HT3SW
10	HT4	MW	HT4MW
11	HT4	PK	HT4PK
12	HT4	SW	HT4SW

HT=Harvesting Time, MW=Mowing, PK=Hand Picking, SW=Sweeping shattered seed on the ground

Data Collection

The experiment was conducted for the period of three years. The collected data were number of inflorescences per meter square, number of racemes per inflorescence, number of spikelet per raceme, seed yield per hectare (SYPH), thousand seed weight, seed viability or germination percentage and plant height. Plot cover and vigor were also scored based on 1 to 10 scales, with the score 10 referring to 100% good plot cover or vigor. Plant height was determined by taking the average heights of five randomly selected plants from each plot. Germination test was carried out by taking 50 randomly selected pure sample seeds per plot in replica. The seeds were then put in labeled Petri-dishes with moistened paper on the bottom. The seeds were allowed to germinate and counting was conducted at regular intervals during the test period.

Germination percent = Number of germinated seeds x 100 divided by total number of seeds tested.

Data Analysis

Data was analyzed using general linear model procedure of statistical analysis system (SAS, 2002-version 9.0). Least significant difference (LSD) test was employed for variables whose F-values declared a significant difference ($P<0.05$). The statistical model for data analysis was $Y_{ijk} = \mu + A_i + B_j + (AB)_{ij} + \varepsilon_{ijk;}$ $i = 1,\ldots, a; j = 1,\ldots,b; k = 1,\ldots,n$

Where: Y_{ijk}= observation k at i^{th} level of harvesting time and j^{th} level of harvesting method; μ= the overall mean; A_i= the i^{th} level effect of harvesting time; B_j= the j^{th} level effect of harvesting method;

$(AB)_{ij}$= the effect of the interaction of i^{th} level of harvesting time with j^{th} level of harvesting method; ε_{ijk}= random error; a= number of levels of harvesting time; b= number of levels of harvesting method; n= number of observations of each factor combinations.

RESULTS AND DISCUSSION

Analysis of variance for the variables measured in the study is shown in Table 2. Seed yield per hectare was significantly (P<0.001) affected by harvesting method. Thousand seed weight also differed significantly (P<0.01) among the harvesting methods. On the other hand, only number of raceme per inflorescence was significantly (P<0.01) affected by harvesting time.

Table 2.Summary of analysis of variance for the different variables measured during the study

Factors	NIPMS	NRPI	NSPR	TSW	SYPH	GP
HM	NS	NS	NS	**	***	NS
HT	NS	**	NS	NS	NS	NS
HM*HT	NS	NS	NS	NS	NS	NS

, *: Significant at the 0.01, 0.001 levels respectively; NS=Non significant; HM=Harvesting Method; HT=Harvesting Time; NIPMS=Number of Inflorescence Per Meter Square; NRPI=Number of Raceme per Inflorescence; NSPR=Number of Spikelet per Raceme; TSW=Thousand Seed Weight; SYPH=Seed Yield Per Hectare; GP=Germination Percentage.

Effect of Harvesting Time on Seed Yield and Quality of *Desmodium uncinatum*

Seed production parameters of *Desmodium uncinatum (Jacq.) DC.*as affected by harvesting time is presented in Table 3. The number of raceme per inflorescence was significantly (P<0.01) affected by harvesting time with the highest value (11.5±0.8) recorded at harvesting time one. According to Puzio-IdKowska (1993), the number of racemes per stem, number of pods per raceme and number of seeds per pod have positive correlation coefficients with seed yield per plant. Plants characterized by a high seed yield also have high number of seeds per raceme (Huyghe *et al.* 1998, 1999). A reduction in number of raceme per inflorescence across the harvesting times might be due to shattering of seed pods. Hacquet (1990) and Rosellini *et al.* (1990) reported positive relationships between seed yield and number of seeds per pod.

Parameters including number of inflorescences per meter square, number of spikelet per raceme, thousand seed weight, seed yield per hectare, germination percentage and plant height did not differ significantly (P>0.05) across the different harvesting time. Although not significant, the average seed yield over the different harvesting time ranged from 123.4±13.7kg ha^{-1} during the fourth harvest to 160.2±13.7 kg ha^{-1} during the first harvest (beginning of fragmentation of early pods). The reduction in seed yield across harvesting time (one to four) might be due to shattering nature of the seed pods. The yields obtained in this study were within the range (50 to 330kg ha^{-1}) reported for Desmodium (Muyekho, 1996).

Effect of Harvesting Method on Seed Yield and Quality of *Desmodium uncinatum*

Table 4 indicates seed production parameters of *Desmodium uncinatum (Jacq.) DC.* as affected by harvesting methods. Seed yield showed significant variation (P<0.001) among the different

harvesting methods. The highest seed yield (281.9±11.8 kg ha^{-1}) was obtained by hand picking method, while the lowest (27.2±11.8 kg ha^{-1}) was recorded in the sweeping method of seed harvesting. The lowest yield obtained might be due to difficulty of collecting small sized *Desmodium uncinatum (Jacq.) DC* seed from the ground. Skerman *et al.* (1988) reported a seed yield of 220-330 kg ha^{-1} from *Desmodium uncinatum (Jacq.) DC* harvested by hand picking. However, Alemayehu *et al.* (2016) reported that *Desmodium uncinatum (Jacq.) DC* can produce up to 400 kg ha^{-1} seed in sub-humid areas of Ethiopia such as Bako.

According to Roder *et al. (*2002) *Desmodium uncinatum (Jacq.) DC* produces higher seed yield than Greenleaf desmodium and is less sensitive to unfavorable conditions. Even though, harvesting by sweeping method resulted in lower seed yield, it resulted in significantly ($P<0.01$) higher thousand seed weight (8.2±0.4) than hand picking (6.3±0.4). This might be attributed to the possibility of collecting large sized seeds from the ground in the sweeping method. In contrast to this finding, Yoshiaki (2012) showed that bigger seeds usually result in better yield, and the seed weight is also important for good seedling vigor upon planting.

Table 3. Effect of harvesting time on seed yield and quality of *Desmodium uncinatum (Jacq.) DC.*

Parameters	Harvesting time (Mean ±SEM)				Over all mean	CV %	Sig
	HT1	HT2	HT3	HT4			
NIPMS	93.4±4.3	85.1±4.3	90.3±4.3	88.1±4.3	89.2	16.8	ns
NRPI	11.5±0.8[a]	7.8±0.8[b]	7.2±0.8[b]	7.8±0.8[b]	8.6	31.3	**
NSPR	22.3±1.2	22.6±1.2	24.0±1.2	21.4±1.2	22.6	18.6	ns
TSW (gm)	7.1±0.5	7.7±0.5	7.6±0.5	6.5±0.5	7.2	23.2	ns
SYPH (kg)	160.2±13.7	152.9±13.7	132.0±13.7	123.4±13.7	142.15	33.3	ns
GP	75.88±6.6	73.95±6.6	79.54±6.6	70.68±6.6	75.01	31.96	ns
Height (cm)	158.9±4.3	157.1±4.3	158.6±4.3	145.6±4.3	155.1	9.6	ns

[ab]Means with different superscripts along the row differ significantly; **Significant at 0.01; ns=non-significant, CV=Coefficient of Variation, NIPMS=Number of Inflorescence Per Meter Square, NRPI=Number of Raceme per Inflorescence, NSPR=Number of Spikelet per Raceme, TSW=Thousand Seed Weight, SYPH: Seed Yield Per Hectare, GP=Germination Percentage, SEM=Standard Error of Means, HT1=Harvesting when the early pods started to fragment; HT2, HT3 and HT4 refer to the harvests made one, two and three weeks after the first harvest, respectively.

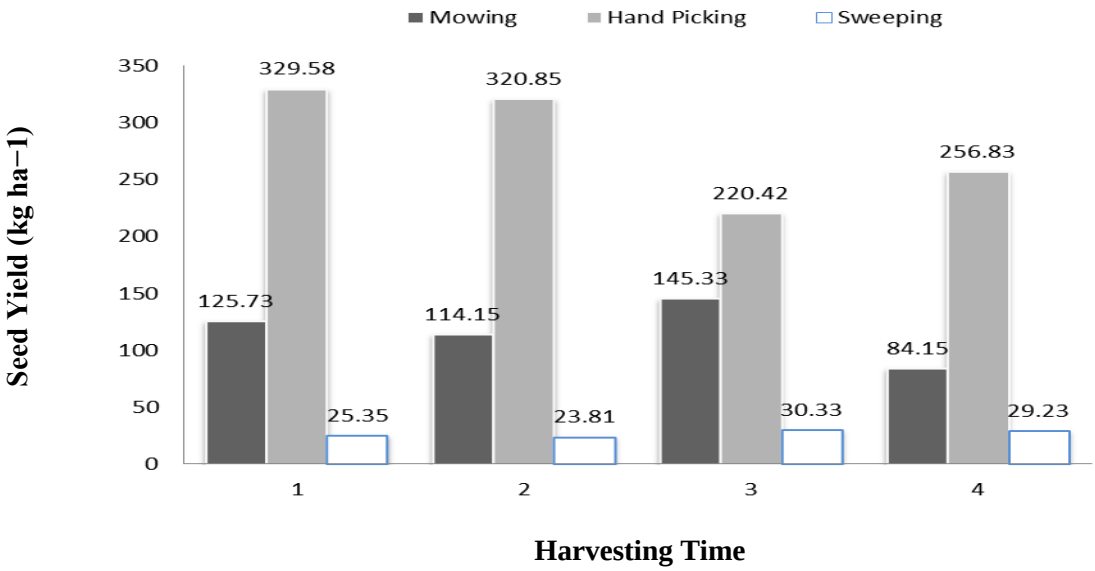
Table 4. Effect of harvesting method on seed yield and quality parameters of *Desmodium uncinatum (Jacq.) DC.*

Parameters	Harvesting methods (Mean±SEM)			Over all mean	CV %	Sig
	Mowing	Hand Picking	Sweeping			
NIPMS	90.4±3.7	94.8±3.7	82.5±3.7	89.2	16.8	ns
NRPI	8.2±0.7	8.6±0.7	8.9±0.7	8.6	31.3	ns
NSPR	21.1±1.1	23.7±1.1	22.9±1.1	22.6	18.6	ns
TSW (gm)	7.1 ± 0.4^{ab}	6.3 ± 0.4^{b}	8.2 ± 0.4^{a}	7.2	23.2	**
SYPH (kg)	117.3 ± 11.8^{b}	281.9 ± 11.8^{a}	27.2 ± 11.8^{c}	142.15	33.3	***
GP	72.49±5.7	74.28±5.7	78.28±5.7	75.01	31.96	ns

[abc]Means with different superscripts along the row differ significantly. **, ***: Significant at 0.01 and 0.001 levels, ns=non-significant, CV=Coefficient of Variation, NIPMS=Number of Inflorescence Per Meter Square, NRPI=Number of Raceme per Inflorescence, NSPR=Number of Spikelet per Raceme, TSW=Thousand Seed Weight, SYPH= Seed Yield Per Hectare, GP=Germination Percentage, SEM= Standard Error of Means.

Effects of Harvesting Method and Time on Seed Yield of *Desmodium uncinatum*

The average seed yield of *Desmodium uncinatum* (Jacq.) DC. at various harvesting methods over the different harvesting times is shown in Figure1. The highest seed yield was obtained during the first harvest (harvesting time1) followed by harvesting time 2 using the hand picking method. Bocsa and Buglos (1983) and Rosellini *et al.* (1990) reported a high correlation of seed yield with number of seeds per pod. The increased numbers of pods and seeds per pod can result in higher number of seeds per raceme. The number of inflorescences per plant is the most important component of seed yield (Taylor and Marble, 1996). Zambrana (1972) also reported that number of seeds per plant was the main component of seed yield and there were also high and positive relationships between seed yield and number of fertile stems, number of seeds per pod and number of inflorescences per plant.



Harvesting time: - 1=beginning of disintegration of early pods; 2, 3 and 4 – one, two and three weeks after the first harvest, respectively

Figure 1. Effects of harvesting method and time on seed yield of *Desmodium uncinatum (Jacq.) DC.*

Effects of Harvesting Method and Harvesting Time on Seed Viability of *Desmodium uncinatum*

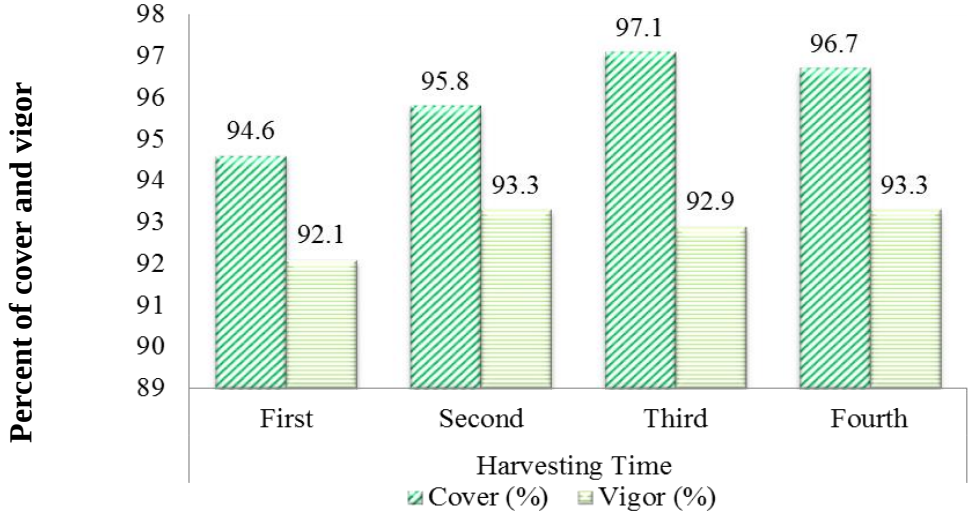
The average viability of *Desmodium uncinatum (Jacq.)DC.*seed as affected by harvesting methods and harvesting times is shown in Table 5. The result showed that germination rate of *Desmodium uncinatum (Jacq.) DC* seed ranged from 62 to 86%. According to Ethiopian Standards (ES505:2000/2012), germination percentage of silver leaf desmodium (*Desmodium uncinatum (Jacq.) DC* seed should be at least 60% to qualify for seed certification. Therefore, the germination percentage recorded in this study can comply with requirements of the Ethiopian Standards.

Table 5. Effects of harvesting method and harvesting time on viability of *Desmodium uncinatum (Jacq.)DC.*seed

Harvesting time	Viability of Seed (%)			Average
	Hand mowing	Hand picking	Sweeping	
Harvesting time one	86.25±18.47	71.4±19.47	70.0±14.99	75.88±6.6
Harvesting time two	70.0±12.73	70.93±12.73	80.93±28.03	73.95±6.6
Harvesting time three	72.1±27.66	80.83±23.02	85.7±15.08	79.54±6.6
Harvesting time four	61.6±29.1	73.95±30.94	76.48±21.97	70.68±6.6
Average	72.49±5.7	74.28±5.7	78.28±5.7	

Effect of harvesting time on ground cover and plant vigor of *Desmodium uncinatum*

The percentage values of ground cover and vigor of Desmodium uncinatum (Jacq.) DC.during different times of seed harvest are shown in Figure 2. It was noted that plant cover was gradually increasing up to harvesting time 3. Moreover, lower plant vigor was recorded at harvesting time 1.



Harvesting time: - First=beginning of disintegration of early pods; 2nd, 3rd and 4th – one, two and three weeks after the first harvest, respectively

Figure 2. Effect of harvesting time on ground cover and vigour of *Desmodium uncinatum (Jacq.) DC.*

Effect of Harvesting Method on Ground Cover and Plant Vigor of *Desmodium uncinatum*

The observed percentage values of ground cover and plant vigor scores of *Desmodium uncinatum (Jacq.) DC.*as affected by harvesting method is presented in Figure 3. Comparatively higher plant cover and vigor scores were recorded when harvesting was made by hand picking than mowing and sweeping methods.

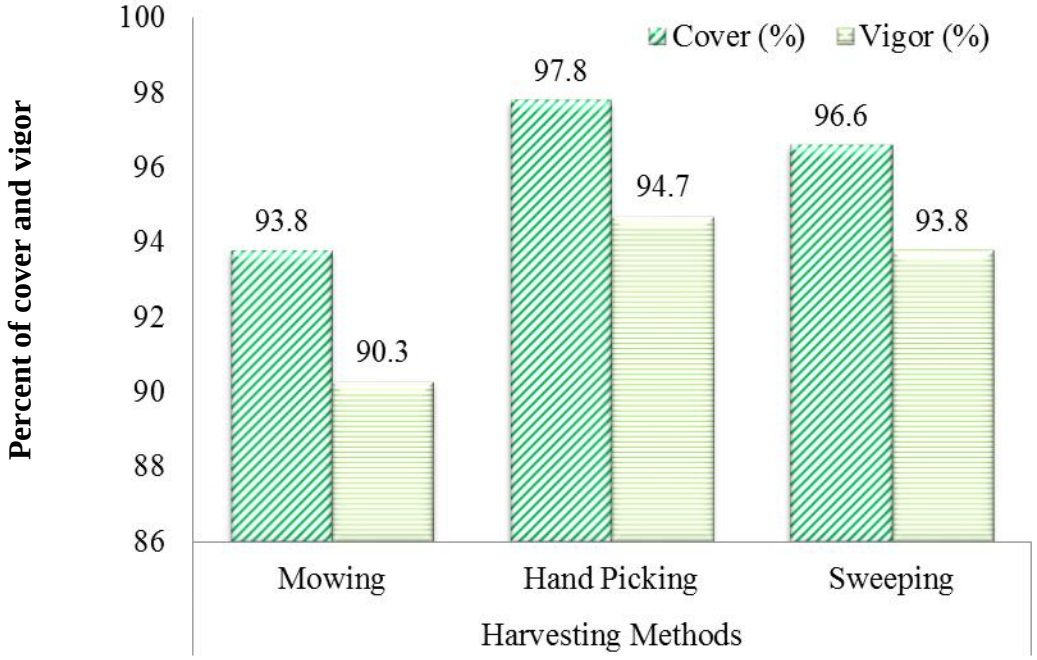


Figure 3.Effect of harvesting method on ground cover and vigour scores of *Desmodium uncinatum (Jacq.) DC.*

CONCLUSIONS

The study revealed that harvesting by hand picking was more efficient for producing large amount of seed than mowing and sweeping methods. Similarly, harvesting within one week following the beginning of disintegration of the early seed pods is more appropriate to produce large quantity of better quality seed than delayed harvesting. Thus, small-scale seed producers may be advised to use hand picking and to harvest within one week time following the beginning of disintegration of the early seed pods to harvest the seeds of *Desmodium uncinatum*.

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