Asian Jr. of Microbiol. Biotech. Env. Sc. Vol. 23, No. (3) : 2021 : 347-352

ISSN-0972-3005

BIO-EFFICACY OF HERBICIDES FOR WEED MANAGEMENT IN MOTH BEAN (*VIGNA ACONITIFOLIA*)

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(Received 6 March, 2021; Accepted 19 May, 2021)

***Key words :** Moth bean, Weed control methods and Yield.*

Abstract– An experiment was carried out during *Kharif* season of 2020 at Crop Research Farm, NAI, SHUATS to evaluate the bio-efficacy of herbicides on growth and yield of moth bean (*Vigna aconitifolia*) and associated weeds. The experiment consisted of 9 treatments which includes hand weeding, pendimethalin as pre-emergence herbicide, fluchloralin as pre-plant incorporation and post emergence herbicide, imazethapyr as post-emergence herbicide and Unweeded (Weedy check). The result revealed that, application of Imazethapyr PoE 50 g/ha had maximum weed control efficiency (39.49%) with minimum weed population (60.33 no./m^2) over all the treatments applied as pre or post-emergence, whereas grassy weeds (85.94 – 91.17 %) recorded the highest relative coverage as compare to broad leaf weeds (5.30 -7.56 %) and sedges (3.53 – 7.63 %) among all the treatments. Application of fluchloralin PPI 0.50 kg/ha recorded highest seed yield (426.17 kg/ha) and B:C ratio (1.74).

INTRODUCTION

Moth bean (*Vigna aconitifolia*) which is also called as *Kheri*, *Dew Bean*, *Kidney Bean*, *Matki*, *Math* and *Turkish Gram*. These are mostly grown in arid and semi-arid regions of India. Moth bean is a good source of protein (24%) and high in dietary fiber. It also contains essential amino acids, particularly lysine and leucine and some vitamins. Uncooked raw moth bean (100gm) have 343 calories, 24 g of protein, 62 g of carbohydrate and 1.6 g of fat. Also green pods are delicious source of vegetable with more protein contain (Kumar *et al.,* 2003). In the country, Moth bean occupied 9.26 lac ha giving 2.77 lac tonnes production during the twelfth plan (2012-2015) period. Major moth bean growing states of India are Rajasthan, Uttar Pradesh, Maharashtra, Gujarat, Haryana and Punjab.

Weeds are unpleasant, undesirable, unwanted plants which interfere negatively with human activities and adversely affect human welfare. Severe weed infestation is the major constraint and may reduce the yield by 30-50% (Singh and Singh, 1979). There are three goals of any weed management system, reduce weed density, reduce the amount of damage that a given density of weeds inflicts on an associated crop and after the composition of weeds communities towards less aggressive and easier to manage species. Conventional methods used for managing weeds in moth bean fields are time consuming and costly. In early stage of the crop, grasses are predominant as compared to others, but at later stage, sedges and broad leaf weeds create interference in crop growth. No doubt that hand weeding is the established effective method on weed control, but now a days high cost involved and unavailability of labours makes weed management more difficult. Chemical weed control is regarded to be better than hand weeding due to drudgery of weeding and comparatively less input. Pendimethalin is basically pre-emergence herbicide. In rainfed condition, if weeds have not yet germinated, this herbicide may be effective when applied after first shower (Singh *et al.,* 2016). Fluchloralin is a selective herbicide which can be applied as pre-plant incorporation and post-emergence treatment. And Imazethapyr is a broad-spectrum herbicide, has soil and foliar activity that allows flexibility in its application timing and has low mammalian toxicity (Tan *et al.,* 2005). Moreover, acute shortage of labor at critical time makes manual weeding operation impossible. Keeping this point in view, an experiment was conducted to find out economical and effective weed management practices in moth bean.

MATERIALS AND METHODS

The experiment was conducted at Central Research Farm, Department of Agronomy, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during *Kharif* 2020. The soil of the experimental site was sandy loam with normal soil reaction (pH = 7.54). The soil was low in organic carbon (0.24%), medium in available nitrogen (256.49 kg/ha), low in available phosphorus (6.90 kg/ha) and medium in available potassium (256.30 kg/ha). The experiment was laid out in Randomized Block Design with nine treatments including hand weeding at 25 DAS; pendimethalin 0.75 and 1.00 kg/ha applied as pre-emergence; fluchloralin 0.50 and 0.75 kg/ha as pre plant incorporation and post emergence; imazethapyr 30, 40 and 50 g/ha applied as post-emergence and unweeded, which replicated thrice (Table 1). Variety used for trial "RMO-40", which was sown with seed rate 12 kg/ha and keeping 45 cm × 10 cm spacing. Herbicide applied with knapsack sprayer through 500 liters of water per hectare. The pre-plant incorporation of herbicide was applied one day before sowing, whereas pre-emergence herbicides applied two days after sowing and post-emergence herbicides applied 25 days after sowing. Weeds were recorded using quadrate 25 cm × 25 cm and converted the values in m^2. The average temperature varies from 26.08 °C- 35.47 °C, relative humidity 51.10- 80.55 % and rainfall 126.60- 279.00 mm during crop period, respectively. Regular observation of crop and weed with key factor like weed parameters and growth attributes of crop were recorded at regular during the crop growth, however the observation data at peak stage means at harvest. The data collected on crop and weeds was subjected to statistical analysis as per procedure (Gomez and Gomez, 1984).

Data on density (no./m^2), weed population (no./m^2), weed control efficiency (%), Absolute frequency of weeds (%) and absolute coverage of weed species (%) recorded species wise separately in each plot at maturity stage. Calculation of this parameters through their formula described in below; a) Weed Density (D): Amount of particular weed species inside of a determined crop area. It is expressed in No./m^2 (Sharma, 2014).

Table 1. Treatments

Treatment No.	Treatment Combinations
1	Hand weeding @ 25 DAS
2	Pendimethalin PE 0.75 kg/ha (at 2 DAS)
3	Pendimethalin PE 1 kg/ha (at 2 DAS)
4	Fluchloralin PPI 0.50 kg/ha (one day before sowing)
5	Fluchloralin PoE 0.75 kg/ha (at 25 DAS)
6	Imazethapyr PoE 30 gm/ha (at 25 DAS)
7	Imazethapyr PoE 40 gm/ha (at 25 DAS)
8	Imazethapyr PoE 50 gm/ha (at 25 DAS)
9	Unweeded (Weedy check)

$$D = \frac{\Sigma i\ Z}{A}$$

Where,
D= Density (in number/m^2) of species in field
Z= Number of plants of a species in quadrant i
A = Area in m^2 of N quadrants in field

b) Weed Control Efficiency (WCE): It indicates the percentage reduction in weed population under treated plot in comparison to untreated plot (Weedy). It is express in % (Patil and Patil., 1983).

$$WCE = \frac{WP_C - WP_T}{WP_C} \times 100$$

Where,
WPC =Weed population in control (Unweeded) plot
WPT =Weed population in treated plot

c) Absolute Frequency of weeds (AF): Count the weed population and differentiate in broad leaf, grassy and sedges in different quadrates and recorded the analysis in which quadrates had no broad leaf or grassy or sedges and expressed in % (Sharma, 2014).

$$AF = \frac{\Sigma i\ Y}{N}$$

Where,
Y = Presence (1) or absence (0) of species in field i
N = Number of field surveyed

d) Relative Coverage: It indicates the percentage of area cover by a particular weed species inside of a determined crop area. It expressed in % (Sharma., 2014).

$$\text{Relative coverage} = \frac{D}{WP} \times 100$$

Where,
D = Density of the given species in unit area
WP = Total weed population in unit area

RESULTS AND DISCUSSION

Weed Flora

Weeds are unpleasant, undesirable, unwanted plants which interfere negatively with human activities and adversely affect human welfare. Through the weed survey of experimental field consisted of broad leaved weeds, grassy and sedges. The common weed species are *Digera muricata, Phyllanthus niruri, Melothria pendula, Cynodon dactylon, Digitaria sanguinalis, Dactyloctenium algyptium* and *Cyperus* spp. (Table 2). Weeds compete with the beneficial vegetation in crops lands, forests etc. weeds are troublesome in many ways. Primarily, they reduce crop yield, reduce crop quality by competing for water, soil, light & nutrients etc.

Effect on Weed

Weed density

Among all weed control treatments, sedges and broad leaf weed show non-significant result ranges between 2.00-7.00 no./m^2, while weed density of grasses significantly reduced from range 53.00 to 86.00 no./m^2. The lowest weed density of broad leaf was recorded with Pendimethalin PE 0.75 kg/ha (3.67/m^2), whereas Imazethapyr PoE 50 g/ha (53.00/m^2) in grassy and Fluchloralin PoE 0.75 kg/ha (2.67/m^2) in sedges (Table 3). Lowest weed density due to, Pendimethalin inhibits root and shoot growth. It controls the weed density and prevents weed emerging, particularly during the crucial development phase of the crop and Imazethapyr translocated freely in plants through the roots and shoots could effectively control broad- leaf as well as grasses (Ram *et al.,* 2012).

Weed population

Different weed control treatments had significant effect on weed population and the lowest weed population recorded with application of Imazethapyr PoE 50 g/ha (60.33/m^2), which was 39.49% more effective from unweeded plot (99.67/m^2). However, Hand weeding @ 25 DAS (66.30 no./m^2), Pendimethalin PE 0.75 kg/ha (66.67 no./m^2), Pendimethalin PE 1 kg/ha (66.67 no./m^2), Fluchloralin PPI 0.50 kg/ha (67.00 no./m^2) and Imazethapyr PoE 40 g/ha (70.00 no./m^2) was closely followed the same trend and reducing weed population respectively (Table 3). The reduction of weeds due to imazethapyr translocated freely in plants through the roots and shoots and compress the growth, which effectively controlled broad- leaf as well as grasses (Ram *et al.,* 2012).

Weed control efficiency

At maturity of crop, maximum weed control efficiency recoded with the application of Imazethapyr PoE 50 g/ha (39.49%), which was statistically at par with Hand weeding @ 25 DAS (33.30%), Pendimethalin PE 0.75 kg/ha (33.02%), Pendimethalin PE 1 kg/ha (32.97%), Fluchloralin PPI 0.50 kg/ha (32.81%) and Imazethapyr PoE 40 g/ha (29.45%) respectively (Table 3). This might be due to better control of grassy weeds which led to less in numbers (Singh *et al.,* 2016).

Absolute frequency and relative coverage of weeds

At maturity of crop, among all the treatments the lowest frequency of weeds recorded with Fluchloralin PoE 0.75 kg/ha (41.67%) in sedges as compare to broad leaf (91.67%) and grassy weeds (100%), whereas Grassy weeds (85.94 – 91.17 %) recorded the highest coverage as compare to broad

Table 2. Weed flora

Botanical name	Common name	Family	Lifecycle	Infestation (%)
Digera muricata	False amaranth	Amaranthaceae	Perennial	6.02
Phyllanthus niruri	Bhumi amla	Euphorbiaceae	Annual	4.01
Melothria pendula	Creeping cucumber	Cucurbitaceae	Perennial	3.01
Cynodon dactylon	Bermuda grass	Poaceae	Annual	66.89
Digitaria sanguinalis	Crab grass	Poaceae	Annual	8.03
Dactyloctenium algyptium	Crow foot grass	Poaceae	Annual	5.02
Cyperus rotundus	Motha purple nutsedge	Cyperacea	Perennial	7.02

leaf weeds (5.30 -7.56 %) and sedges (3.53 – 7.63 %) among all the treatments (Table 3).

The absolute frequency and relative coverage highest in grassy weeds may be due to the predominant and fast growing nature of grasses among broad leaf weeds and sedges.

Effect on growth parameters

The values related to plant population, there was no significant variation among the treatments. Maximum no. of plant population recorded with the application of Fluchloralin PPI 0.50 kg/ha (22.00/m^2) (Table 4). The reason behind this, plant population will depend upon the germination capacity of the seed and suitable climatic condition of the crop. Heavy rainfall decreases the plant population which hamper in germination of seed because moth bean is a drought condition crop (Kumar *et al.*, 2003). Significantly maximum plant height recorded with application of Imazethapyr PoE 30 g/ha (29.75 cm), which was significantly superior over all the treatments (Table 4). Maximum plant height may be due to better availability of moisture, nutrient, light and space (Komal *et al.*, 2015; Chandrakar *et al.*, 2014; Choudhary *et al.*, 2017). No. of branches/plant is an important component of pulse crops which helps to increase in seed yield. Application of Imazethapyr PoE 40 g/ha recoded maximum no. of branches per plant (3.60), there was no significant variance among the treatments (Table 4). Maximum no. of nodules/plant was recorded with Hand weeding @ 25 DAS (6.40), which was statistically at par with application of Pendimethalin PE 0.75 kg/ha (6.00), Pendimethalin PE 1 kg/ha (5.80), Fluchloralin PPI 0.50 kg/ha (6.27) and Imazethapyr PoE 30 g/ha (5.60) (Table 4). The increase in effective root nodules per plant may be due to availability of nutrients and rhizobia in soil. These findings are in close conformity with Raman and Krishnamoorthy (2005). Maximum dry weight was recorded with application of Fluchloralin PPI 0.50 kg/ha (7.57 g/plant). There was no significant difference among the all treatments. Control plot (weedy check) gave minimum dry weight (6.06 g/plant) (Table 4). Maximum plant dry weight may be because of better management of weeds during early crop growth which resulted in higher dry weight of plant (Hanumanthappa *et al.*, 2012).

Effect on yield and economics

Seed yield of the crop was distinctly influenced by the weed management treatments. The maximum

Table 3. Effect of herbicides on weed at maturity

Treatments	Weed Density (No./m^2)			Weed population (No./m^2)	Weed control Efficiency (%)	Absolute Frequency of Weeds (%)			Relative coverage of weeds (%)		
	Broad leaf	Grassy	Sedges			Broad leaf	Grassy	Sedges	Broad leaf	Grassy	Sedges
Hand weeding @ 25 DAS	4.33	57.67	4.33	66.30	33.30	75.00	100.00	83.33	6.66	86.60	6.71
Pendimethalin PE 0.75 kg/ha	3.67	58.67	4.33	66.67	33.02	75.00	100.00	83.33	5.59	87.92	6.48
Pendimethalin PE 1 kg/ha	4.67	58.00	4.00	66.67	32.97	91.67	100.00	75.00	6.82	87.10	6.08
Fluchloralin PPI 0.50 kg/ha	5.00	57.00	5.00	67.00	32.81	100.00	100.00	75.00	7.56	84.80	7.63
Fluchloralin PoE 0.75 kg/ha	4.00	68.33	2.67	75.00	24.46	91.67	100.00	41.67	5.30	91.17	3.53
Imazethapyr PoE 30 g/ha	5.00	71.67	4.33	81.00	18.77	83.33	100.00	66.67	5.95	88.61	5.44
Imazethapyr PoE 40 g/ha	4.67	59.67	5.67	70.00	29.45	100.00	100.00	83.33	6.66	85.06	8.28
Imazethapyr PoE 50 g/ha	4.00	53.00	3.33	60.33	39.49	75.00	100.00	66.67	6.71	87.85	5.44
Unweeded (weedy check)	7.00	85.67	7.00	99.67	0.00	100.00	100.00	83.33	7.08	85.94	6.97
SE(m)±	1.00	4.38	0.89	4.59	4.56	9.57	6˜	13.68	1.29	1.70	1.34
CD (P=0.05)	NS	13.14	NS	13.78	13.68	NS	6˜	NS	NS	NS	NS

seed yield was obtained with the application of Fluchloralin PPI 0.50 kg/ha (426.17 kg/ha), which was statistically at par with Pendimethalin PE 0.75 kg/ha (395.35 kg/ha), Fluchloralin PoE 0.75 kg/ha (395.57 kg/ha) and Imazethapyr PoE 50 g/ha (398.24 kg/ha). Fluchloralin PPI 0.50 kg/ha (426.17 kg/ha) gave 41.28% higher seed yield over Unweeded (Table 5). Stover yield was obtained maximum with the application of Pendimethalin PE 0.75 kg/ha (2655.10 kg/ha) followed by Fluchloralin PPI 0.50 kg/ha (2448.91 kg/ha), Hand weeding @ 25 DAS (2368.99 kg/ha) and Imazethapyr PoE 30 g/ha (2187.52 kg/ha) (Table 5). Pendimethalin PE 0.75 kg/ha (2655.10 kg/ha) gave 25.68% higher stover yield over Unweeded. The reduction in yield under the Unweeded plot may be due to presence of higher number of weeds which reduced plant growth and number of plants and number of pods per unit area. The loss in yield due to heavy rainfall was occurred during crop growing period which results to flower drop and pod damage. Pulses are very sensitive, especially in early vegetative stage, flowering and pod formation stage and during that period heavy rain fall cause yield loss (Rosenzweig and Liverman, 1992). Higher gross return (39279.90 Rs/ha), net return (24926.30 Rs/ha) and B:C ratio (1.74) was obtained with the application of Fluchloralin PPI 0.50 kg/ha. Higher gross return and net return in these treatments was primarily due to higher seed and straw yields obtained from moth bean (Table 5). The effective herbicide control lead to increase yield and ultimately increase return more. Preplant incorporation of fluchloralin gave high return due to low cost in weed control with their application. Similar finding were also observed by Saxena *et al.* (2003).

CONCLUSION

The application of Imazethapyr PoE 50 g/ha was

Table 4. Efficacy of herbicides on growth parameters at maturity

treatments	Plant Population (No.)	Plant Height (cm)	Branches/ plant (No.)	Nodules/ plant (No.)	Plant dry weight (g/plant)
Hand weeding @ 25 DAS	20.33	25.68	3.47	6.40	6.69
Pendimethalin PE 0.75 kg/ha	20.67	24.9.	3.47	6.00	6.48
Pendimethalin PE 1 kg/ha	20.33	23.27	3.53	5.80	5.84
Fluchloralin PPI 0.50 kg/ha	22.00	24.97	3.33	6.27	7.57
Fluchloralin PoE 0.75 kg/ha	19.67	25.32	3.40	4.40	7.23
Imazethapyr PoE 30 g/ha	21.00	29.75	3.47	5.60	7.26
Imazethapyr PoE 40 g/ha	20.33	26.25	3.60	4.73	6.52
Imazethapyr PoE 50 g/ha	21.00	24.13	2.80	4.73	6.57
Unweeded (weedy check)	18.00	26.91	3.47	4.80	6.06
SE(m)±	0.78	1.16	0.28	0.46	1.11
CD (P=0.05)	NS	2.46	NS	1.37	NS

Table 5. Efficacy of herbicides on yield and economics of moth bean

Treatments	Seed yield (kg/ha)	Stover yield (kg/ha)	Gross return (INR/ha)	Net return (INR/ha)	B:C Ratio
Hand weeding @ 25 DAS	306.91	2368.99	30140.90	14167.30	0.89
Pendimethalin PE 0.75 kg/ha	395.35	2655.10	37619.45	23318.35	1.63
Pendimethalin PE 1 kg/ha	309.46	1905.63	28916.10	14572.50	1.02
Fluchloralin PPI 0.50 kg/ha	426.17	2448.91	39279.90	24926.30	1.74
Fluchloralin PoE 0.75 kg/ha	395.57	2081.27	35897.90	21454.30	1.49
Imazethapyr PoE 30 g/ha	319.57	2187.52	30541.40	16349.80	1.15
Imazethapyr PoE 40 g/ha	271.73	1869.54	25792.30	11594.70	0.82
Imazethapyr PoE 50 g/ha	398.24	2093.09	36130.30	21926.70	1.54
Unweeded (weedy check)	250.21	1973.11	24665.05	11091.45	0.82
SE(m)±	10.54	171.46	–	–	–
CD (P=0.05)	31.60	514.04	–	–	–

found more effective on weeds in moth bean under Uttar Pradesh climatic condition, whereas Fluchloralin PPI 0.50 kg/ha has been found more effective on yield and economics in moth bean.

ACKNOWLEDGEMENT

I express gratitude to my advisor Dr. (Mrs.) Shikha Singh and all the faculty members of Department of Agronomy for constant support and guidance to carry out the whole experimental research study.

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