Original Research Article

https://doi.org/10.20546/ijcmas.2017.612.372

Economic Analysis of Application of Weed Management Practices in Kharif and Summer Mungbean [Vigna radiata (L.) Wilczek]

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A B S T R A C T

This study investigates the economics of different weed management practices in kharif and summer mungbean [Vigna radiata (L.) Wilczek] under the Punjab (India) conditions. The field experiments (Experiment 1 and Experiment 2) were conducted during kharif 2016 and summer 2017 with ten different weed management treatments by replicating thrice in Randomized Complete Block Design (RCBD). Application of pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + hand weeding (HW) at 4 weeks after sowing (WAS) and pendimethalin 30 EC + imazethapyr 2 SL (pre-mix) at 0.45 kg ha\(^{-1}\) + HW at 4 WAS recorded statistically similar net returns with two HW at 4 and 6 WAS during both the seasons. Application of pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + HW at 4 WAS, pendimethalin 30EC at 0.75 kg ha\(^{-1}\) and imazethapyr 10 SL at 75 g ha\(^{-1}\) at 15 days after sowing (DAS) recorded higher, though statistically similar, B:C ratio than with two HW at 4 and 6 WAS. Pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + HW at 4 WAS, pendimethalin 30 EC at 0.75 kg ha\(^{-1}\) and imazethapyr 10 SL at 75 g ha\(^{-1}\) at 15 DAS can act as alternative to two HW where labour is costly or not available at appropriate time for manual weeding in mungbean.

Keywords

Benefit cost ratio, Gross returns, Herbicides, Imazethapyr, Net returns, Pendimethalin

Introduction

Mungbean [Vigna radiata (L.) Wilczek] is the third most important pulse crop in India (Tiwari and Shivhare 2016). Mungbean contains 22-28% protein, 60-65% carbohydrates, 1-1.5% fat, 3.5-4.5% fibre and 4.5-5.5% ash (Anonymous, 2017). Due to its short duration and being adaptable to be grown during both the summer and the kharif season, mungbean is a good potential crop to be used under intensive cropping systems. In addition to providing additional income to the farmers, it also provides sustainability to the agriculture system by enriching soil with nitrogen through biological nitrogen fixation (BNF) process. Weed management is very important aspect for obtaining higher productivity of the crop. Uncontrolled weed flora reduced grain yield in mungbean by 47-76% (Singh et al., 2015), in mash [Vigna mungo L. Hepper] by 38% (Aggarwal et al., 2014) and in soybean [Glycine max L. Merrill] by 40-51% (Ram et al., 2013). Weeds can be effectively controlled by hand weeding (Sekhon et al., 1996; Singh et al., 2002; Singh et al., 2010). However, decrease in labour availability and increased cost of cultivation are the major bottleneck for manual removal of weeds by hand weeding. The usage of herbicides in Indian agriculture is increasing due to high
yield losses by weeds, decreasing labour availability and increasing knowledge about their use among the farmers. Thus, it becomes even more important to find out economically viable herbicide treatments which can substitute the traditional manual hand weeding practices, increasing the profit to farmers and reducing the drudgery of human labour.

Herbicides have shown promising results in controlling weeds and improving grain yield of various pulses (Kaur et al., 2009; Singh, 2011; Singh and Sekhon, 2013; Singh et al., 2014a; Singh et al., 2016). Ram et al., (2012) studied the effect of imazethapyr in French bean (Phaseolus vulgaris L.) and observed that application of imazethapyr at 50 g ha⁻¹ 20 DAS significantly reduced the plant height, branches plant⁻¹, and grains pod⁻¹ as compared to two HW at 20 and 40 DAS. However, grain yield and grain index remained at par with two HW treatment. Application of imazethapyr 10 SL at 75 or 100 g ha⁻¹ at either 15 or 25 DAS in soybean recorded higher net income and benefit cost ratio as compared with that in two HW treatment (Ram et al., 2013). In groundnut (Arachis hypogea L.) application of pendimethalin at 1.0 kg ha⁻¹ + HW at 45 DAS increased pod yield as compared to that in two HW at 20 and 35 DAS Kumar et al., (2013). In chickpea (Cicer arietinum L.) pendimethalin at 1.0 kg ha⁻¹ recorded grain yield and straw yield statistically similar with two hoeing + HW at 30 DAS Bhutada and Bhale (2015). Patel et al.,(2016) reported that application of pendimethalin + imazethapyr at 0.75 kg ha⁻¹ and 1.0 kg ha⁻¹ recorded statistically at par grain yield to that in HW twice in field pea (Pisum sativum L.). Higher benefit cost ratio was recorded in pendimethalin at 1.0 kg ha⁻¹ than HW twice, which might be due to reduced cost of HW. Reduction in weed competition, high grain yield and low input cost of herbicides result in high net returns. Problem of timely and low cost availability of human labour for hand weeding could also be solved by using economical herbicides.

In mungbean, pendimethalin, imazethapyr and pendimethalin + imazethapyr (pre-mix) are the promising herbicides. Pendimethalin is an herbicide of the di-nitroaniline class, used for control of annual grasses and certain broadleaf weeds. It inhibits cell division and cell elongation. Imazethapyr is an imidazolinone herbicide that effectively controls a broad spectrum of weed species. These herbicides kill plants by inhibiting acetohydroxy acid synthase (AHAS). Use of pendimethalin, imazethapyr and pendimethalin + imazethapyr in mungbean may be found effective in increasing monetary benefits to farmers by reducing the labour requirement thus lowering cost of production and lowering the drudgery of farmer and his family. Therefore, these herbicides were tested in kharif as well as summer mungbean.

**Materials and Methods**

The present study was conducted in two experiments i.e., Experiment 1 (kharif 2016) and Experiment 2 (summer 2017) at research farm of Pulses Section, Department of Plant Breeding and Genetics, Department, Punjab Agricultural University, Ludhiana. The soil of Experiment 1 had medium organic carbon (0.61%), low available nitrogen content (144 kg ha⁻¹), high available phosphorus (28.5 kg ha⁻¹) and medium available potassium (161 kg ha⁻¹). The soil of Experiment 2 was low in organic carbon (0.36%) and had low available nitrogen content (130 kg ha⁻¹), medium available phosphorus (16.2 kg ha⁻¹) and medium available potassium (158 kg ha⁻¹). Both the experiments were laid out in Randomized Complete Block Design (RCBD) replicated three times with ten treatments (viz. pendimethalin 30 EC at 0.45 kg ha⁻¹ pre-
emergence (PE) + HW at 4 WAS, pendimethalin 30 EC at 0.75 kg ha\(^{-1}\) (PE), pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha\(^{-1}\) (PE) + HW at 4 WAS, pendimethalin 30 EC + imazethapyr 2 SL at 0.75 kg ha\(^{-1}\) (PE), imazethapyr 10 SL at 50 g ha\(^{-1}\) at 15 or 25 DAS, imazethapyr 10 SL at 75 g ha\(^{-1}\) at 15 or 25 DAS, two HW at 4 & 6 WAS and weedy check).

Applications of herbicides were done by using water at 500 L ha\(^{-1}\). Pre-emergence herbicides were applied in the evening on the day of sowing of crop. Post-emergence herbicides treatments were also applied in the evening at 15 and 25 DAS as per the treatments.

The sowing of mungbean in Experiment 1 (cultivar ML 2056) was done on 20\(^{th}\) July, 2016 at a row spacing of 30 cm using a seed rate of 20 kg ha\(^{-1}\). Mungbean in Experiment 2 (cultivar SML 832) was sown on 28\(^{th}\) March, 2017 at a row spacing of 22.5 cm using a seed rate of 30 kg ha\(^{-1}\). Whole amount of nitrogen at the rate of 12.5 kg ha\(^{-1}\) and phosphorus at the rate of 40 kg ha\(^{-1}\) was applied at the time of sowing in both experiments. Experiment 1 was harvested on 8 October, 2016 while, Experiment 2 was harvested on 8 June, 2017. The crop was raised as per the recommendations (PAU 2016, PAU 2017).

**Total variable costs**

For calculating total variable costs, the total costs of cultivation (i.e. total variable costs) were taken into account for both the experiments. Cost of cultivation varied with the treatments applied. The cost of cultivation included money spends on seed, fertilizers, seed inoculation, weed management practices, human labour, insecticides, irrigation etc. The details of all the costs involved in different inputs used in Experiments 1 and 2 are presented in Tables 1 and 2, respectively. It was expressed as Rs ha\(^{-1}\).

**Gross returns**

For calculating gross returns, the grain yield was multiplied by minimum support price (MSP) and the stover yield was multiplied with prevalent market price. This was denoted in Rs ha\(^{-1}\). Gross returns calculated for the Experiment 1 and Experiment 2 are presented in Tables 3 and 4. The formula implied for calculations is given below.

\[
\text{Gross returns} = [\text{Grain yield (kg ha}^{-1}) \times \text{Rs 52.25 kg}^{-1}] + [\text{Stover yield (kg ha}^{-1}) \times \text{Rs 1.20 kg}^{-1}]
\]

**Net returns**

Net returns were calculated by subtracting total variable costs from the gross returns. It was expressed as Rs ha\(^{-1}\).

\[
\text{Net returns} = \text{Gross returns} - \text{Total variable costs}
\]

**Benefit cost ratio**

The benefit cost ratio was calculated by dividing the net returns with the variable costs.

\[
\text{Benefit cost ratio} = \frac{\text{Net returns}}{\text{Total variable costs}}
\]

**Results and Discussion**

**Total variable costs**

The highest total variable cost in both the experiments was recorded in two HW at 4 and 6 WAS followed by pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha\(^{-1}\) + HW at 4 WAS and pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + HW at 4 WAS (Tables 3 and 4). The lowest total variable costs were recorded in weedy check. Application of post-emergence applications of imazethapyr 10 SL recorded lower total variable costs as compared to pre-
emergence herbicide treatments. Two HW treatment recorded in 32.4 and 33.3% higher total variable costs as compared with weedy check in Experiment 1 and Experiment 2, respectively. Application of imazethapyr 10 SL at 50 g ha\(^{-1}\) at 15 and 25 DAS recorded lowest increase in total variable costs (1.79 and 1.81% in Experiment 1 and Experiment 2, respectively) as compared to weedy check.

**Gross returns**

In Experiment 1, the highest gross returns were recorded in two HW treatment, which were statistically at par with that in pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + HW at 4 WAS and pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha\(^{-1}\) + HW at 4 WAS (Table 3).

In Experiment 2, application of pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + HW at 4 WAS recorded statistically similar gross returns with that in two HW treatment (Table 4). Application of other herbicide treatments recorded significantly lower gross returns as compared to that in two HW treatment.

Higher gross returns recorded in these treatments could be due to higher grain and stover yield. Weedy check reduced gross returns by 51.31 and 48.25% as compared to two HW at 4 and 6 WAS treatment in Experiment 1 and Experiment 2, respectively. Similar results for pendimethalin and imazethapyr were recorded by Singh et al., (2015) and pendimethalin + imazethapyr by Lhungdim et al., (2013).

In both experiments, among the post-emergence herbicide treatments, application of imazethapyr 10 SL at 75 g ha\(^{-1}\) at 15 DAS recorded highest gross returns followed by that in imazethapyr 10 SL at 50 g ha\(^{-1}\) at 15 DAS (Tables 3 and 4). Applications of imazethapyr 10 SL at 50 and 75 g ha\(^{-1}\) at 15 DAS recorded higher gross returns as compared to that in imazethapyr 10 SL at 50 and 75 g ha\(^{-1}\) at 25 DAS as also recorded by Singh et al., (2014b). The lowest gross returns were recorded in weedy check, in both kharif and summer mungbean (Tables 3 and 4).

**Net returns**

In Experiment 1, the highest net returns were recorded in two HW at 4 and 6 WAS treatment, which were statistically at par with that in pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + HW at 4 WAS and pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha\(^{-1}\) + HW at 4 WAS (Table 3). Application of pendimethalin 30 EC at 0.75 kg ha\(^{-1}\) and imazethapyr 10 SL at 75 g ha\(^{-1}\) at 25 DAS recorded high net returns. Weedy check recorded the lowest net returns, reducing 68.67% as compared to two HW at 4 and 6 WAS.

In Experiment 2, application of pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + HW at 4 WAS, pendimethalin 30 EC at 0.75 kg ha\(^{-1}\), pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha\(^{-1}\) + HW at 4 WAS and imazethapyr 10 SL at 75 g ha\(^{-1}\) at 15 DAS recorded statistically at par net returns with that in two HW treatment (Table 4). High net returns recorded in these treatments could be due to higher grain yield and stover yield and lower total costs by usage of herbicides. Weedy check resulted in the maximum reduction (68.46%) in net returns. Application of imazethapyr 10 SL at 50 g ha\(^{-1}\) at 15 DAS and imazethapyr at 75 g ha\(^{-1}\) at 15 DAS recorded higher net returns as compared to that in imazethapyr 10 SL at 50 g ha\(^{-1}\) at 15 DAS and imazethapyr at 75 g ha\(^{-1}\) at 25 DAS, in both experiments. Lowest net returns were recorded in weedy check (Tables 3 and 4). Similar findings for pendimethalin, imazethapyr and pendimethalin + imazethapyr were also reported by Chandrakar et al., (2014).
**Table 1** Price of produce and inputs used to calculate the economics in Experiment 1

| Particulars       | Item                                      | Quantity (ha<sup>-1</sup>) | Price unit<sup>-1</sup> (Rs) | Total (Rs) |
|-------------------|-------------------------------------------|----------------------------|-----------------------------|------------|
| **Returns**       | Grain yield                               | 52.25 kg<sup>-1</sup>      |                             |            |
|                   | Stover yield                              | 1.20 kg<sup>-1</sup>       |                             |            |
| **Variable Costs**|                                           |                            |                             |            |
| **Seed and seed** | **treatment**                             |                            |                             |            |
|                   | Seed                                      | 20 kg                      | 110 kg<sup>-1</sup>         | 2200       |
|                   | Seed treatment                            | 60 g                       | 600 kg<sup>-1</sup>         | 36         |
|                   | Seed inoculation                          | 2.5 packets                | 20                          | 50         |
| **Fertilizers**   | Urea                                      | 27 kg                      | 544 q<sup>-1</sup>          | 150        |
|                   | SSP                                       | 250 kg                     | 660 q<sup>-1</sup>          | 1650       |
| **Plant Protection** | Ekalux                                    | 4 L (2 L + 2 L)           | 536 L<sup>-1</sup>          | 2144       |
|                   | Indoxacarb                                | 500 ml                     | 2200 L<sup>-1</sup>         | 1100       |
|                   | Triazophos                                | 1.5 L                      | 420 L<sup>-1</sup>          | 630        |
| **Miscellaneous** | Irrigation                                | 2                          | 60                          | 120        |
|                   | Human Labour                              | 425 hours                  | 40                          | 17000      |
|                   | Tractor hours                             | 7.5 hours                  | 360                         | 2700       |
| **Treatment cost**|                                           |                            |                             |            |
|                   | Pendimethalin 30 EC at 0.45 kg ha<sup>-1</sup> (PE) + HW at 4 WAS | 1.5 L + 1 + 15 | 675+5250 | 5925       |
|                   | Pendimethalin 30 EC at 0.75 kg ha<sup>-1</sup> (PE) | 2.5 L + 1 | 1125+750 | 1875       |
|                   | Pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha<sup>-1</sup> (PE) + HW at 4 WAS | 1.4 L + 1 + 15 | 625+5250 | 5875       |
|                   | Pendimethalin 30 EC + imazethapyr 2 SL at 0.75 kg ha<sup>-1</sup> (PE) | 2.4 L + 1 | 1776+750 | 2526       |
|                   | Imazethapyr 10 SL at 50 g ha<sup>-1</sup> at 15 DAS | 500 ml + 1 | 500+750 | 1250       |
|                   | Imazethapyr 10 SL at 50 g ha<sup>-1</sup> at 25 DAS | 500 ml + 1 | 500+750 | 1250       |
|                   | Imazethapyr 10 SL at 75 g ha<sup>-1</sup> at 15 DAS | 750 ml + 1 | 750+750 | 1500       |
|                   | Imazethapyr 10 SL at 75 g ha<sup>-1</sup> at 25 DAS | 750 ml + 1 | 750+750 | 1500       |
|                   | Two hand weedings at 4 and 6 WAS          | 0 + 30                     | 9000                        | 9000       |
| **Weedy check**   |                                           | 0                          | 0                           | 0          |
Table 2: Price of produce and inputs used to calculate the economics in Experiment 2

| Particulars          | Item                          | Quantity (ha⁻¹) | Price unit (Rs) | Total (Rs) |
|----------------------|-------------------------------|-----------------|-----------------|------------|
| **Returns**          |                               |                 |                 |            |
|                      | Grain yield                   | 52.25 kg⁻¹      |                 |            |
|                      | Stover yield                  | 1.20 kg⁻¹       |                 |            |
| **Variable Costs**   |                               |                 |                 |            |
|                      | Seed and seed treatment       |                 |                 |            |
|                      | Seed                          | 30 kg           | 110 kg⁻¹        | 3300       |
|                      | Seed treatment                | 90 g            | 600 kg⁻¹        | 54         |
|                      | Seed inoculation              | 5 packets       | 20              | 100        |
|                      | Fertilizers                   |                 |                 |            |
|                      | Urea                          | 27 kg           | 544 q⁻¹         | 150        |
|                      | SSP                           | 250 kg          | 660 q⁻¹         | 1650       |
|                      | Plant Protection              |                 |                 |            |
|                      | Ekalux                         | 2 L (1 L + 1 L) | 536 L⁻¹         | 1072       |
|                      | Indoxacarb                    | 1 L             | 2200 L⁻¹        | 2200       |
|                      | Triazophos                    | 1.5 L           | 420 L⁻¹         | 630        |
|                      | Dimethoate                    | 250 ml          | 330 L⁻¹         | 85         |
|                      | Miscellaneous                 |                 |                 |            |
|                      | Irrigation                    | 5               | 60              | 300        |
|                      | Human Labour                  | 370 hours       | 40              | 14800      |
|                      | Tractor hours                 | 7.5 hours       | 360             | 2700       |
| **Treatment cost**   |                               |                 |                 |            |
|                      | Pendimethalin 30 EC at 0.45 kg ha⁻¹ (PE) + HW at 4 WAS | 1.5 L + 1 + 15 | 675+5250 | 5925       |
|                      | Pendimethalin 30 EC at 0.75 kg ha⁻¹ (PE) | 2.5 L + 1 | 1125+750 | 1875       |
|                      | Pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha⁻¹ (PE) + HW at 4 WAS | 1.4 L + 1 + 15 | 625+5250 | 5875       |
|                      | Pendimethalin 30 EC + imazethapyr 2 SL at 0.75 kg ha⁻¹ (PE) | 2.4 L + 1 | 1776+750 | 2526       |
|                      | Imazethapyr 10 SL at 50 g ha⁻¹ at 15 DAS | 500 ml + 1 | 500+750 | 1250       |
|                      | Imazethapyr 10 SL at 50 g ha⁻¹ at 25 DAS | 500 ml + 1 | 500+750 | 1250       |
|                      | Imazethapyr 10 SL at 75 g ha⁻¹ at 15 DAS | 750 ml + 1 | 750+750 | 1500       |
|                      | Imazethapyr 10 SL at 75 g ha⁻¹ at 25 DAS | 750 ml + 1 | 750+750 | 1500       |
|                      | Two hand weedings at 4 and 6 WAS | 0 + 30  | 9000 | 9000       |
|                      | Weedy check                   |                 |                 | 0          |
Table 3 Effect of herbicide treatments on economic analysis in Experiment 1

| Treatment                                                                 | Total variable costs (Rs ha⁻¹) | Returns (Rs ha⁻¹) | B: C |
|---------------------------------------------------------------------------|--------------------------------|------------------|------|
| Total variable costs (Rs ha⁻¹)                                           |                                |                  |      |
| Pendimethalin 30 EC at 0.45 kg ha⁻¹ (PE) + HW at 4 WAS                     | 32955                          | 88618            | 55663| 1.69 |
| Pendimethalin 30 EC at 0.75 kg ha⁻¹ (PE)                                  | 28905                          | 76663            | 47758| 1.65 |
| Pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha⁻¹ (PE) + HW at 4 WAS | 33345                          | 85737            | 52392| 1.57 |
| Pendimethalin 30 EC + imazethapyr 2 SL at 0.75 kg ha⁻¹ (PE)               | 29556                          | 69529            | 39973| 1.35 |
| Imazethapyr 10 SL at 50 g ha⁻¹ at 15 DAS                                  | 28280                          | 68525            | 40275| 1.42 |
| Imazethapyr 10 SL at 50 g ha⁻¹ at 25 DAS                                  | 28280                          | 61267            | 32987| 1.17 |
| Imazethapyr 10 SL at 75 g ha⁻¹ at 15 DAS                                  | 28530                          | 74187            | 45657| 1.60 |
| Imazethapyr 10 SL at 75 g ha⁻¹ at 25 DAS                                  | 28530                          | 56703            | 28173| 0.99 |
| Two hand weedings at 4 and 6 WAS                                          | 36780                          | 93633            | 56853| 1.55 |
| Weedy check                                                               | 27780                          | 45588            | 17808| 0.64 |
| CD (p=0.05)                                                               | 9093                           | 9093             | 0.30 |

Table 4 Effect of herbicide treatments on economic analysis in Experiment 2

| Treatment                                                                 | Total variable costs (Rs ha⁻¹) | Returns (Rs ha⁻¹) | B: C |
|---------------------------------------------------------------------------|--------------------------------|------------------|------|
| Total variable costs (Rs ha⁻¹)                                           |                                |                  |      |
| Pendimethalin 30 EC at 0.45 kg ha⁻¹ (PE) + HW at 4 WAS                     | 32166                          | 70762            | 38596| 1.20 |
| Pendimethalin 30 EC at 0.75 kg ha⁻¹ (PE)                                  | 28116                          | 61952            | 33836| 1.20 |
| Pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha⁻¹ (PE) + HW at 4 WAS | 32556                          | 66855            | 34299| 1.05 |
| Pendimethalin 30 EC + imazethapyr 2 SL at 0.75 kg ha⁻¹ (PE)               | 28767                          | 61060            | 32293| 1.12 |
| Imazethapyr 10 SL at 50 g ha⁻¹ at 15 DAS                                  | 27491                          | 58618            | 31127| 1.13 |
| Imazethapyr 10 SL at 50 g ha⁻¹ at 25 DAS                                  | 27491                          | 51850            | 24359| 0.89 |
| Imazethapyr 10 SL at 75 g ha⁻¹ at 15 DAS                                  | 27741                          | 63942            | 36201| 1.31 |
| Imazethapyr 10 SL at 75 g ha⁻¹ at 25 DAS                                  | 27741                          | 49062            | 21321| 0.77 |
| Two hand weedings at 4 and 6 WAS                                          | 35991                          | 77374            | 41383| 1.15 |
| Weedy check                                                               | 26991                          | 40044            | 13053| 0.48 |
| CD (p=0.05)                                                               | 7940                           | 7940             | 0.28 |

**Benefit cost ratio**

A benefit cost ratio helps to realize the relationship between the costs and benefits involved in a system. If the value of benefit cost ratio is higher than 1, it indicates the net profit involved. Value less than 1 of benefit cost ratio indicates net losses. General thumb rule is that if the benefit is higher than the cost involved in the project, it can be considered as good investment.

In Experiment 1, application of pendimethalin 30 EC at 0.45 kg ha⁻¹ + HW at 4 WAS recorded maximum benefit cost ratio, however, all the herbicide treatments except
imazethapyr 10 SL at 50 and 75 g ha\(^{-1}\) at 25 DAS recorded benefit cost ratio statistically at par with that in two HW (Table 3). In Experiment 2, the highest benefit cost ratio was observed in imazethapyr 10 SL at 75 g ha\(^{-1}\) at 15 DAS. Application of all the herbicide treatments except imazethapyr 10 SL at 75 g ha\(^{-1}\) at 25 DAS recorded statistically similar benefit cost ratio with that in two HW. The lowest benefit cost ratio was observed in weedy check in both experiments. Results are in line with the findings of Khairnar et al., (2014) and Balyan et al., (2016).

It can be concluded that application of HW recorded highest gross (Rs 93633 in Experiment 1 and Rs 77374 in Experiment 2) and net returns (Rs 56863 during Experiment 1 and Rs 41383 in Experiment 2). Application of pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + HW at 4 WAS (1.69) and imazethapyr 10 SL at 75 g ha\(^{-1}\) at 15 DAS (1.31) recorded highest benefit cost ratio in Experiment 1 and Experiment 2, respectively. Therefore, it can be concluded that HW twice is recommended for higher returns, however, pendimethalin 30 EC at 0.45 kg ha\(^{-1}\) + HW, pendimethalin 30 EC at 0.75 kg ha\(^{-1}\), pendimethalin 30 EC + imazethapyr 2 SL at 0.45 kg ha\(^{-1}\) + HW at 4 WAS and imazethapyr 10 SL at 75 g ha\(^{-1}\) at 15 DAS can act as alternative where labour was costly or not available at appropriate time for manual weeding in mungbean.

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**How to cite this article:**

Rukinderpreet Singh and Guriqbal Singh. 2017. Economic Analysis of Application of Weed Management Practices in *Kharif* and Summer Mungbean [*Vigna radiata* (L.) Wilczek]. *Int.J.Curr.Microbiol.App.Sci.* 6(12): 3182-3190. doi: [https://doi.org/10.20546/ijemas.2017.612.372](https://doi.org/10.20546/ijemas.2017.612.372)