**Assessment of Weed management practices in linseed (*Linum usitatissimum* L.)**

**ABSTRACT**

A field experiment was carried out during *rabi* 2024 on loamy sand soil of Agronomy Instructional Farm, C. P. College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar to find out the most effective weed management practices in linseed. The experiment was laid out in RBD with four replications having eight different weed management practices. The result revealed that weed free treatment recorded significantly higher seed and stover yield (1588 and 2408 kg/ha, respectively) and found at par with pendimethalin @ 750 g/ha as PE *fb* one interculturing at 30 DAS and one HW at 45 DAS (1407 and 2272 kg/ha, respectively), two HW at 30 and 45 DAS (1382 and 2235 kg/ha, respectively), pendimethalin @ 750 g/ha as PE *fb* clodinafop + metsulfuron methyl @ 64 g/ha as PoE (1379 and 2160 kg/ha, respectively), pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE (1312 and 2042 kg/ha, respectively) as compared to weedy check (902 and 1566 kg/ha, respectively) due to suppression of weeds at 60 DAS and at harvest with higher weed control efficiency and lower weed index values. Moreover, pendimethalin @ 750 g/ha as PE *fb* clodinafop + metsulfuron methyl @ 64 g/ha as PoE recorded higher net returns (₹43797/ha) and B:C ratio (2.06) as compared to weedy check.

Keywords**:** Linseed, Weed management, Weed index, Weed Control Efficiency, Quality

**1. Introduction**

 “ The crop is often grown under minimum agronomic management practices, which adversely affects the crop yield and quality of produce. Weed management is one of the most important factors to obtain good quality produce. The crop is severely affected by weed competition during its early growth phase” (Mohanty and Sahoo, 2022; Alam *et al*., 2021). “Linseed (*Linum usitatissimum* L.) is one of the oldest cultivated crops grown for seed and fibre. Linseed also known as flaxseed, belongs to the family *Linaceae.* It is native to the region extending from the Eastern Mediterranean to India. It is worldwide cultivated commonly for flax, while in India it is cultivated for oil. Linseed is unique among oilseeds for its technical grade vegetable oil-producing ability and fiber (good quality having high strength and durability) production. Linseed contains 35 to 45% oil with high content of omega-3 fatty acid, alpha lenolenic acid (ALA). Linseed oil contains three times as much omega-3 fatty acid as omega-6 fatty acid” (Singh *et al.*, 2013). “Its seed has 36% protein out of which 85% is digestible. Its oil cake is used to feed milch and fattening animals for milk and meat production. Its oil has a lot of uses apart from human consumption *viz*., oil paint, varnishes, printing ink, oilcloth, soap, patent leather and waterproof fabrics due to its fast volatility feature” (Sharma *et al.*, 2015). “Madhya Pradesh, Karnataka, Jharkhand, Bihar, Uttar Pradesh and Chhattisgarh are the leading states in linseed production in India” (Anonymous, 2021). “In India, the linseed crop was cultivated in the area of 2.28 lakh ha and production is 161 thousand tonnes” (Anonymous, 2023). “India is the second largest (21.21%) linseed-growing country in the world after Canada and production-wise, it ranks fourth (8.20%) in the world after Canada (40.51%), China (18.68%) and USA (10.89%)” (Shaikh *et al*., 2021). “Among *rabi* oilseed crops in India, linseed occupies the second position (next to rapeseed-mustard) in importance from the point of view of area as well as production. It is a good source of calcium and phosphorus with their contents of 170 and 370 mg/100 g, respectively” (Kasana *et al*., 2018).

“The crop weed management is an important factor contributing for higher production. Nowadays, various varieties of linseed have been released by ICAR and State Agricultural Universities for getting higher productivity. It is imperative to find out the agronomic requirements of newly released varieties to exploit their yield potential. The selection of appropriate weed management practices is the most important factor for securing higher yields in a particular climate. Therefore, there is a need to identify the best weed management practice for this particular agro-climatic zone. An initial growth period of 25-45 days is very critical and season-long weed competition has been found to reduce linseed yield to the extent of 30-40 %” (Mahere *et al*., 2000). “The initial slow growth with lower canopy spread leads to the dominance of weeds over the crop. Farmers rely predominately on manual weeding, a traditional method of weed control in oilseeds in general and linseed in particular. Though the conventional methods of weed control are very effective, they are expensive, labour-intensive and time-consuming during the critical period. This necessitates the development of an alternative cost-effective economically viable weed management practice that can serve as a substitute for manual weeding. In that, herbicide use is making a headway. Pre-mixed application of as pre-emergence, early post-emergence and post-emergence herbicides was found effective elsewhere for weed control in linseed and other oilseed crops” (Siddesh *et al.*, 2016) but region-specific information is needed. Therefore, the management of weeds through economically viable methods is more important for enhancing the productivity of linseed in a sustainable manner in Gujarat. Weeds can be controlled by different methods such as manual, mechanical and chemical methods. Generally, for weed management, farmers do manual weeding, but it is always laborious, expensive, time-consuming, and uneconomical and needs to be often repeated at different intervals, as compared to chemical weed management. Weed management with herbicides is effective, quick in action, and time-saving.

**2. Material and Methods**

 An experiment was conducted during *rabi* season 2024 at Agronomy Instructional Farm, Department of Agronomy, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat. The experimental plot was loamy sand in texture, low in organic carbon and available nitrogen, medium in available phosphorus and high in available potassium status. The experiment was laid out in Randomized Block Design and four replications with eight treatments comprising of weed management practices *viz*., [T1: Weed-free (up to 60 DAS), T2: Two hand weeding at 30 and 45 DAS, T3: Pendimethalin @ 750 g/ha as PE *fb* one IC at 30 DAS and one HW at 45 DAS, T4: Pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE at 30 DAS, T5: Pendimethalin @ 750 g/ha as PE *fb* imazethapyr @ 75 g/ha as PoE at 30 DAS, T6: Pendimethalin @ 750 g/ha as PE fb clodinafop propargyl + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS, T7: Pendimethalin @ 750 g/ha as PE *fb* 2,4-D @ 500 g/ha as PoE at 30 DAS, T8: Weedy check]. Fertilizer application was done as per the recommended dose of fertilizers. Full dose of phosphorus and 50% nitrogen were applied as basal dose in form of SSP and urea respectively, while the remaining 50% nitrogen was applied in one split at 30 DAS in the form of urea. The crop was sown at 30 cm spacing by using a uniform seed rate of 20 kg/ha. Thinning was carried out at 30 DAS keeping a uniform distance between two plants to maintain equal plant population in all the plots. During the growing season of the crop two hand weedings at 30 and 45 DAS were carried out manually in particular treatments and one interculturing at 30 DAS was done in particular treatments to keep the experimental plots weed free and pulverize the soil for better aeration. The biometric observations were recorded from five randomly selected tagged plants within each net plot for all parameters *viz*., plant height (cm), number of branches per plant, number of capsules per plant, number of seeds per capsule, test weight (g), seed yield (kg/ha), stover yield (kg/ha),harvest index (%) and oil content (%) in seed which was determined by Nuclear Magnetic Resonance, gross return, net return and BCR. The data recorded for various parameters during the course of investigation were statistically analysed by a producer appropriate to the design of experiment as described by Panse and Sukhatme (1985). The significance of difference was tested by “F” test at 5 per cent level.

**3. Result and discussion**

**3.1 Effect on weed flora, weed density and weed dry weight of linseed**

The experimental field was infested with *Cyperus rotundus* L. among sedges, *Cynodon dactylon* L., *Asphodelus tenuifolius* among grasses, *Chenopodium album* L., *Digera arvensis* L., *Amaranthus viridis* L., *Euphorbia lathyrism* L., *Leucus aspera* L., *Boerhavia erecta* L. and *Cammelina benghalensis* L. among broad leaf weeds. Among, sedges *Cyperus rotundus* L., among grasses *Cynodon dactylon* L. and among broad-leaf weeds *Digeria arvensis* L. was dominant at all stages. Siddesh *et al*. (2016) also observed similar weed flora in linseed.

Different weed management practices exhibited significant effect on total weed density and total dry weight at 60 DAS and at harvest. Weed-free check recorded significantly lower total weed density and total dry weight at 60 DAS. In case of herbicide treatments, significantly lower total density and total dry weight of weeds was recorded with the application of pendimethalin @ 750 g/ha as PE *fb* one IC at 30 DAS and one HW at 45 DAS followed by pendimethalin @ 750 g/ha as PE *fb* clodinafop + metsulfuron methyl @ 64 g/ha as PoE. Weedy check recorded significantly higher total weed density and total dry weight. This might be due to pre-emergence herbicide treatment i.e. pendimethalin, which inhibits both cell division and cell elongation in shoot and root meristem of susceptible weed species. Growth is inhibited directly following absorption through shoot and hypocotyls. The ready mixture of clodinafop + metsulfuron methyl is responsible for inhibiting the enzyme acetyl CoA carboxylase (ACCase) and acetolactate synthase (ALS) in weed plants which is essential for synthesis of lipids and amino acids in grassy and broad leaf weeds respectively. Inhibition of amino acid and lipids production subsequently stop cell division and causes mortality of the susceptible weeds. Thus, the combination has effectively controlled the category-wise and lead to total weeds at 60 DAS. Similar results were also noticed by Alam and Shabnam (2021) where in application of clodinafop + metsulfuron methyl @ 64 g/ha as post-emergence was very effective against weeds.

**3.2 Effect on weed control efficiency and weed index of linseed**

Weed-free check recorded significantly higher weed control efficiency at harvest
(99.21 %). In case of herbicides treatments, application of pendimethalin @ 750 g/ha as PE *fb* clodinafop + metsulfuron methyl @ 64 g/ha as PoE recorded significantly higher weed control efficiency (86.00 %) followed by pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE (84.10 %).These results were supported by the findings of Alam and Shabnam (2021) and Singh *et al*. (2019) who observed higher weed control efficiency due to post-emergence application of pendimethalin @ 750 g/ha as PE *fb* clodinafop + metsulfuron methyl @ 64 g/ha as PoE.

Different weed management practices varied the weed index of linseed at harvest
(Table 1). Among the herbicide treatments, a significantly lower weed index was recorded with the application of pendimethalin @ 750 g/ha as PE *fb* clodinafop + metsulfuron methyl @ 64 g/ha as PoE (7.59 %) followed by pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE (11.02 %). However, Weedy check recorded a significantly higher weed index (39.38 %) (Table 1). These findings are by Singh *et al*. (2019) who was clear from the data that the weed competition index (crop yield loss) in comparison to hand weeding twice was recorded maximum with weedy check (51.25%) and minimum with clodinafop @ 60 g/ha + metsulfuron methyl @ 4 g/ha (11.80%) due to variation in growth and yield attributes of linseed as well as weedy density and dry matter of weeds.

**3.3 Effect on growth, yield and quality of linseed**

 All the growth and yield attributes were significantly higher under application of pre and post-emergent herbicides. Weed-free check treatment recorded significantly superior growth and yield attributes as compared to other treatments including weedy check. Among herbicidal treatments, significantly higher plant height (56.50 cm), number of primary branches (4.60) and number of capsules per plant (48.20) were recorded with application of pendimethalin @ 750 g/ha as PE *fb* clodinafop propargyl + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS. Followed by pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE at 30 DAS. This might be attributed to initial vigorous crop growth restricted the growth of weeds that has indirectly boosted the plants to record higher growth parameters and also characteristics of better utilization of solar energy and nutrients during plant growth which has contributed to an increased growth of crop and also weed control by different treatments which resulted into less or nearly no crop weed competition for nutrients, light, moisture and space which leads to higher accumulation of photosynthesis. Thus, it clearly indicates that increased weed population adversely affect the yield parameters in linseed. Singh *et al*. (2019) and Singh *et al*. (2021) also observed “similar results wherein post-emergence application of pendimethalin @ 750 g/ha as PE *fb* clodinafop propargyl + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS”.

 Among the herbicide treatments application of pendimethalin @ 750 g/ha as PE *fb* clodinafop propargyl + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS showed that significantly higher seed yield and stover yield (1375 and 2160 kg/ha, respectively). Followed by pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE at 30 DAS (1312 and 2149 kg/ha, respectively) (Table 3). Significantly lower seed yield and stover yield was recorded with weedy check (902 and 1566 kg/ha, respectively).The enhanced yields under these treatments were due to the control of weeds which helped in enhancing the availability of nutrients, space, sunlight and water resulting in better growth and development of crop plants. Mahajan and Khande (2020) and Puhup and Dwivedi (2019) also observed “significantly higher seed yield of linseed with post-emergence application of metsulfuron methyl @ 4g/ha”.

 Weed-free check recorded significantly higher gross returns (₹82760) as compared to all other treatments. Among herbicide treatment, application of pendimethalin @ 750 g/ha as PE fb clodinafop propargyl + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS (₹76410) as compared to other treatments and it was found at par with pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE at 30 DAS (₹72997). Whereas, lower gross returns were observed with weedy check (₹50274) due to poor yield (Table 3).

 Among herbicide treatment significantly higher net returns were recorded in the application of pendimethalin @ 750 g/ha as PE *fb* clodinafop propargyl + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS (₹39288) and it was found at par with pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE at 30 DAS (₹37485). Whereas, significantly lower net returns were recorded weedy check (₹17123).

 Significantly higher BC ratio was recorded with application of pendimethalin @ 750 g/ha as PE fb clodinafop propargyl + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS (2.06) and pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE at 30 DAS (2.06) both treatments are same. The lower BC ratio (1.52) was recorded in the weedy check. Herbicide treatments offer an alternative method of selective and economical control of weeds right from the beginning, giving crop an advantage of good start and competitive superiority and found to be cheaper than hand weeding for effective management of weeds and economic returns in linseed. These results conformed with the findings of Singh *et al.* (2019) and Singh *et al* (2021) who reported that “application of clodinafop @ 60 g/ha + Metsulfuron methyl @ 4 g/ha at 2-3 leaf stage of weeds was found superior in respect of various growth and yield attributes *viz*., plant height, number of branches per plant, number of pods per plant, higher seed yield and straw yield of linseed”.

**4. Conclusion**

Based on the results of one year of experimentation, it is concluded that higher seed yield and net returns through effective weed management practices in linseed can be secured with two-hand weeding at 30 and 45 DAS. In labour crisis conditions, application of pendimethalin @ 750 g/ha as PE *fb* clodinafop + metsulfuron methyl @ 64 g/ha as PoE or pendimethalin @ 750 g/ha as PE *fb* metsulfuron methyl @ 4 g/ha as PoE.

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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**Table 1: Effect of weed management practices on weed density, weed dry weight, weed control efficiency and weed index of linseed**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment** | **Weed density** | **Weed Dry Weight** | **Weed control efficiency (%)** | **Weed index (%)** |
| **30 DAS** | **60 DAS** | **At harvest** | **30 DAS** | **60 DAS** | **At harvest** |
| T1: | Weed free (up to 60 DAS) | 0.71(0.0) | 0.71(0.0) | 1.86(3.0) | 0.71(0.0) | 0.71(0.0) | 1.21(0.98) | 99.21 | - |
| T2: | Two hand weeding at 30 and 45 DAS | 8.91(79.0) | 4.22(17.5) | 4.51(20.0) | 4.64(21.06) | 2.01(3.62) | 3.67(13.04) | 89.49 | 7.12 |
| T3: | Pendimethalin @ 750 g/ha as PE *fb* one IC at 30 DAS and one HW at 45 DAS | 6.95(48.0) | 3.78(14.0) | 4.21(17.5) | 3.00(8.52) | 1.58(2.07) | 3.26(10.20) | 91.78 | 5.44 |
| T4: | Pendimethalin @ 750 g/ha as PE *fb* Metsulfuron methyl @ 4 g/ha as PoE at 30 DAS | 6.83(46.5) | 5.31(28.0) | 5.64(31.5) | 2.98(8.40) | 3.27(10.25) | 4.48(19.72) | 84.10 | 11.02 |
| T5: | Pendimethalin @ 750 g/ha as PE *fb* Imazethapyr @ 75 g/ha as PoE at 30 DAS | 6.59(43.5) | 6.35(40.0) | 7.09(50.0) | 2.88(7.82) | 4.13(16.75) | 4.45(29.27) | 76.40 | 17.41 |
| T6: | Pendimethalin @ 750 g/ha as PE *fb* Clodinafop + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS | 6.51(42.0) | 5.08(25.5) | 5.30(28.0) | 2.84(8.64) | 3.07(9.00) | 4.22(17.37) | 86.00 | 7.59 |
| T7: | Pendimethalin @ 750 g/ha as PE *fb* 2,4-D @ 500 g/ha as PoE at 30 DAS | 6.64(44.0) | 6.04(36.0) | 6.19(38.0) | 2.96(8.39) | 4.10(16.41) | 5.25(27.19) | 78.08 | 16.53 |
| T8: | Weedy check | 9.27(85.5) | 9.47(89.5) | 9.55(91.0) | 4.71(21.87) | 10.23(104.51) | 11.13(124.03) | - | 39.38 |
| S.Em.± | 0.30 | 0.23 | 0.28 | 0.14 | 0.18 | 0.24 | **-** | **-** |
| C.D. (P=0.05) |  |  |  |  |  |  | **-** | **-** |

**Table 2:Effect of weed management practices on growth, yield attributes and quality of linseed**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Plant population at harvest (meter row length)** | **Plant height at harvest (cm)** | **No. of branches per plant** | **No. of capsule per plant** | **No. of seeds per capsule** | **Test weight (g)** | **Oil content (%)** |
| T1: | Weed free (up to 60 DAS) | 19.15 | 59.75 | 5.20 | 54.45 | 8.10 | 7.24 | 38.30 |
| T2: | Two hand weeding at 30 and 45 DAS | 18.80 | 58.70 | 4.75 | 49.65 | 7.85 | 6.97 | 38.01 |
| T3: | Pendimethalin @ 750 g/ha as PE *fb* one IC at 30 DAS and one HW at 45 DAS | 18.50 | 59.12 | 4.80 | 51.80 | 7.90 | 6.73 | 37.86 |
| T4: | Pendimethalin @ 750 g/ha as PE *fb* Metsulfuron methyl @ 4 g/ha as PoE at 30 DAS | 17.95 | 54.44 | 4.35 | 47.45 | 7.70 | 6.54 | 37.21 |
| T5: | Pendimethalin @ 750 g/ha as PE *fb* Imazethapyr @ 75 g/ha as PoE at 30 DAS | 18.60 | 51.96 | 4.25 | 41.75 | 7.60 | 6.51 | 37.62 |
| T6: | Pendimethalin @ 750 g/ha as PE *fb* Clodinafop + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS | 18.65 | 56.50 | 4.60 | 48.20 | 7.75 | 6.57 | 37.85 |
| T7: | Pendimethalin @ 750 g/ha as PE *fb* 2,4-D @ 500 g/ha as PoE at 30 DAS | 18.00 | 52.20 | 4.30 | 42.55 | 7.65 | 6.50 | 37.24 |
| T8: | Weedy check | 18.85 | 50.53 | 4.00 | 32.40 | 7.55 | 6.47 | 36.73 |
| S.Em.± | 0.60 | 2.23 | 0.23 | 2.41 | 0.28 | 0.18 | 0.82 |
| C.D. (P=0.05) | NS | 6.55 | 0.68 | 7.10 | NS | NS | NS |

**Table 3:Effect of weed management practices on yield and economics of linseed**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Treatments** | **Seed Yield****(kg/ha)** | **Stover Yield****(kg/ha)** | **Harvest index (%)** | **Gross returns (₹/ha)** | **Net returns (₹/ha)** | **BCR** |
| T1: | Weed free (up to 60 DAS) | 1488 | 2408 | 38.19 | 82760 | 39060 | 1.89 |
| T2: | Two hand weeding at 30 and 45 DAS | 1382 | 2235 | 28.21 | 76863 | 38438 | 2.00 |
| T3: | Pendimethalin @ 750 g/ha as PE *fb* one IC at 30 DAS and one HW at 45 DAS | 1407 | 2272 | 28.25 | 78250 | 38916 | 1.99 |
| T4: | Pendimethalin @ 750 g/ha as PE *fb* Metsulfuron methyl @ 4 g/ha as PoE at 30 DAS | 1312 | 2149 | 37.91 | 72997 | 37485 | 2.06 |
| T5: | Pendimethalin @ 750 g/ha as PE *fb* Imazethapyr @ 75 g/ha as PoE at 30 DAS | 1229 | 1964 | 38.49 | 69330 | 32174 | 1.89 |
| T6: | Pendimethalin @ 750 g/ha as PE *fb* Clodinafop + metsulfuron methyl @ 64 g/ha as PoE at 30 DAS | 1375 | 2160 | 38.91 | 76410 | 39288 | 2.06 |
| T7: | Pendimethalin @ 750 g/ha as PE *fb* 2,4-D @ 500 g/ha as PoE at 30 DAS | 1242 | 1998 | 28.34 | 69066 | 33414 | 1.94 |
| T8: | Weedy check | 902 | 1566 | 36.54 | 50274 | 17123 | 1.52 |
| S.Em.± | 62.09 | 92.24 | 1.61 | **----** | **-----** | **-----** |
| C.D. (P=0.05) | 183 | 271 | NS | **-----** | **-----** | **-------** |