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Integrated weed management in mustard

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Abstract
Rapeseed-mustard is a significant edible oilseed crop in India. Productivity has grown as a result of technological advancements in rapeseed-mustard production. However, several biotic stressors, such as weeds, cause significant output losses of up to 45 percent in rapeseed-mustard. They lower crop yield and quality by competing for nutrient availability, water, land, and light resources, and they also have an impact on the agro ecosystem. These crops are affected by a variety of weeds, although the level of harm in terms of productivity and resources varies by region. Many weeds are crop and/or region-specific. *Orobanche aegyptiaca*, for example, has become a severe danger in rainfed areas of Rajasthan, Madhya Pradesh, and Haryana, while *Chenopodium*, *Asphodelus*, *Melilotus*, and *Trianthema* spp. cause considerable yield losses in other location. Unlike other oilseed crops, mustard is more susceptible to weed competition in the early phases of development, particularly between 20 and 40 days after sowing. Weed control in mustard is accomplished both by cultural and herbicidal methods. Different dinitroaniline herbicides are routinely employed to eradicate weed species, and the majority of them are only effective against a limited number of weed species. Thus, combining herbicide at crucial development phases with one or two hand weeding at the appropriate time to optimise crop weed suppression yields a large increase in crop production. Fluchloralin and pendimethalin, alone or in conjunction with manual weeding, were shown to be the most cost-effective 30 days after planting.

Keywords: Biotic stressors, agro ecosystem, herbicidal methods, dinitroaniline herbicides, nutrient availability

Introduction
Mustard is a prominent rabi oilseed crop in India. In terms of productivity acreage, peanuts are second and in India mustards are world's major producers. India's contribution to global output is 11%, placing it fourth in the world behind China, Canada, and Germany. Among the many oilseeds, mustard has an area of 6.18 million hectares, a total production of 7.36 million tonnes, and a yield of 1190 kg/ha (Anonymous, 2010) [36]. In Gujarat, the mustard crop area is around 2.23 lakh hectares, with a total production of 3.49 lakh tonnes and a yield of 1568 kg/ha (Anonymous, 2011) [11].
Weeds are one of the biggest challenges to mustard productivity since they reduce yields. Weeds compete with crops for available nutrients, water, light and CO2. According to Rao (2000) [2], agricultural production loss is directly related to weed competition. Weeds diminish photosynthetic activity, dry matter production, and photosynthesis distribution to economically important areas, hence altering the source-sink relationship and reducing mustard yield. Aside from that, they raise production costs, cause insect and plant disease problems, and reduce farm produce quality and land value.

Losses caused by weeds in mustard
Weed losses in mustard seed yield depend on weed population, composition, growth behaviour, and other factors. Tomar and Namdeo (1991) [3] found a 30 percent drop in mustard seed output, whereas others reported a 19-42 percent loss in mustard seed yield (Singh *et al*., 1992a) [34]. Singh *et al*, (1992b) [4] discovered a yield loss of 20-30% in mustard, which climbed to 62% under extreme competition. Crop production losses of up to 34% (Ali, 1993) [5], 44.5 percent (Kaneria and Patil, 1995) [19], and 56% in mustard (Patil *et al*., 1997) [6] have also been documented. It is also highly parasitized by *Orobanche aegyptiaca* Pers, which causes 15–49% seed production loss (Khattri, 1997) [7]. Control of weed species including such annual ryegrass (*Lolium rigidum*) and wild radish (*Raphanus raphanistrum*) in canola is essential to achieving a viable canola harvest because both weeds are a major and widespread problem in Australia. Almost all of the canola grown in Western Australia is triazine resistant due to a gene (selected by traditional breeding methods) infusing resistance to triazine

herbicides (e.g. atrazine and simazine). Thus, the presence of the triazine resistance gene resulted in a 10–20% reduction in crop production (and a 2–3% decrease in oil content) when compared to similar types without triazine resistance (Holt and Thill, 1994 [8]; Moore and Carmody, 1997) [9]. Purna *et al*. (2006) [10] found that the presence of weeds during the growth season reduced mustard seed output by 36-42 percent. Under the All India Coordinated Project on Rapeseed-Mustard, mustard yield loss ranged from 18.1 percent (Ludhiana) to 41.7 percent (Varanasi) (Anonymous, 2011) [11].

Weed Management

Weeds produce an alarming drop in crop productivity, ranging from 15–30% to a total disaster in rapeseed-mustard yield. The key time is between 15 and 40 days. Weeds fight for water, light, space, and nutrients with agricultural plants. As a result, early and proper weed treatment boosts crop production and consequently fertiliser usage efficiency. *Chenopodium album*, *C. murale*, *Cyperus rotundas*, *Cynodondactylon*, *Melilotus alba*, *Asphodelus tenuifolius*, *Orobanche* spp., and *Anagallis arvensis* are the most frequent mustard weeds. Farmers have used herbicides for weed control because the chemicals may boost profit, weed control efficiency, production flexibility, and minimise weed management time and labour requirements. Broomrape (Orobanche) is a destructive mustard parasitic weed. Broomrape plant invasion reduced Indian mustard output by 28.2 percent on average. Among the Orobanche spp., O. aegyptiaca is the most serious parasitic weed causing severe production and quality reduction in rapeseed-mustard. It is prevalent in semiarid regions and can reach epidemic levels depending on soil moisture and temperature.

Cultural method of weed control

Cultural weed control

Cultural weed control: Cultural traditions were essential in this sense prior to the advent of herbicides. Improving crop competitiveness against weeds might give a low-cost and safe weed control technique. Weed control differences across crops or cultivars have long been documented. Aggressive cultivars that grow alongside weeds have a suffocating impact on the weeds. Crop types differ greatly in terms of weed competition. Kumar and Kondap (1992) [12] discovered a modest resistance to a significant parasitic weed, Orobanche sp. of mustard, in the Durgamani variety of mustard. Under the All India Coordinated Research Project on Rapeseed-Mustard, an examination of the competitiveness of rapeseed-mustard varieties against weeds and their effect on mustard yield in 2010-11 revealed that different varieties responded differently to weed competitive ability in terms of yield. At 60 DAS, the Ashirwad variety of mustard produced the highest seed yield with the lowest weed density and weed dry weight, whereas the Kranti variety produced the highest weed competitive ability with higher seed yield and lower weed density and weed dry weight than other selected varieties in the region (Anonymous, 2011) [11].

Weeds are also affected by plant density. Increased crop canopy per unit area by adjusting plant density has a major influence on weed growth suppression (Bhan, 1992) [13]. Singh (2006) [14] showed that raising the seed rate reduced weed population and dry matter generation, which had an influence on mustard seed yield. He discovered that the lowest seed rate of 4 kg/ha resulted in much greater weed density and dry matter accumulation than higher seed rates of 5 and 6 kg/ha. This decrease in weed density and dry matter under increased seed rates might be attributable to weed suppression caused by larger plant population per unit area increasing crop canopy.

Mechanical method of weed control

The first operational requirement in decreasing weed problems is a proper tillage system. Primary tillage activities that bury as many weeds as possible at deeper levels in the soil can limit the total weed population that will germinate. Deep tillage measures prior to mustard seed sowing have become more important in controlling most annual weeds such as *Anagallis arvensis* and *Medicago denticulta*, as well as perennial weeds such as Convolvolus arvensis (Ali and Kumar, 2000) [15]. Farmers in India have been weeding by hand since the beginning of agriculture. Makowshi (1990) [16] recommended mechanical weed management in an East German experiment and found weed cover decreased, particularly of volunteer cereals in oilseed rape stands. Stands. Hoeing twice a year, in early spring and early fall, proved extremely effective. In addition to reducing weed cover, hoeing enhanced production owing to better soil structure and plant development. Rajput *et al*. (1993) [17] got the maximum seed yield of 23.20 q/ha with hand weeding twice in contrast to the control (4.84 q/ha) and other treatments such as hand weeding or hoeing once, pendimethalin and isoproturon at 0.75-1.0 kg for weed control in mustard cv. Pusa Bold. In mustard, Bhadoria and Chauhan (1994) [18] found that manual weeding at 25 DAS produced a greater seed yield (1.44 t/ha) than fluchloralin or hand weeding at 45 DAS. Kaneria and Patel (1994 and 1995) [19, 33] also found that continuously weeded plots and twice-hand weeding at 25 and 45 DAS resulted in reduced weed dry weight and greater weed control efficacy than herbicidal treatments. Gogoi and Kalita (1995) [20] discovered that hand weeding twice at 20 and 40 DAS led in 51.7% weed control effectiveness and the lowest weed dry weight of 23.88 g/m2, and that wheel hoeing, hand hoeing, or grubbings were all equally successful. However, when administered once at 25 DAS, none of these techniques achieved a better degree of weed control effectiveness. Mechanical weeding methods include the use of hand hoes and wheel hoes, among other tools. Hand or wheel hoeing is a faster and less expensive post-planting intercultural activity.

Conservation tillage with surface mulching also aids with successful weed management. Bazaya *et al*. (2006) [21] discovered that polythene mulch was efficient in weed control by raising soil warmth and serving as a physical barrier to weed emergence.

Soil solarization for at least two weeks during the hot summer months (May and June in India) is also adequate to suppress weeds, although it can be extended for several weeks for a longer impact. It has the potential to manage weeds in crops both during the wet season (kharif) and later in the winter (rabi). Singh reported a 90 percent reduction in Orobanche infestation in mustard owing to soil solarization in Israel (2011).

Chemical method of weed control

Herbicides are powerful instruments in man's ongoing battle with weeds. Herbicides, when applied correctly, can achieve their goal in a safe and effective manner. All weeds may be controlled using selective herbicides. As a result, a farmer must be aware of the prevalent weed species in his field in order to select the herbicides that will be used.

Biological method of weed control

It is a biological approach of weed management that involves the use of living creatures such as insects, fungi, bacteria, viruses, and competing plants to restrict weed invasion. Various bioagents for weed control have been found in rapeseed-mustard. According to Sharma *et al*. (2011) [23], Fusarium solani infection on Orobanche increased the frequency of dead spikes of broom rape. Orobanche's natural enemies include insects like Phytomyza orobanchia and fungus like Fusarium oxysporum sp. orthoceras. Many nations' Orobanche seed output has been drastically diminished (Kroschel and Klein, 2003).

Integrated method of weed management

To control huge diversity of weeds in agricultural fields, no one strategy, such as cultural, mechanical, chemical, or biological, could achieve the requisite degree of weed control efficacy in a single place or across sites. These have resulted in the development of integrated weed management (IWM), which involves keeping or controlling a population below a threshold level that does not cause significant economic harm to crops. Thus, an integrated weed management system is defined as a science-based decision-making process that coordinates the use of macro and micro environmental information, weed biology and ecology, and all available technologies to control weeds in the most cost-effective and environmentally sustainable ways (Sanyal, 2008) [25]. Many advancements in integrated weed management in mustard have been accomplished in India in recent years. Several study articles (Chauhan *et al*., 1993 [28]; Singh *et al*., 1999 [27]; Yadav, 2004; Degra *et al*., 2006 [29]; Singh, 2006 [14]; Singh *et al*., 2009) [35] have demonstrated that combining herbicides with manual weeding is the most successful and cost-efficient approach of weed control in rapeseed-mustard.

Table 1: The most economical integrated weed management practice for managing weeds in rapeseed

Integrated weed management practice	Reference
Pendimethalin (2 DAS) at 0.75 kg in combination with hand weeding once at 30 or 40 DAS	Chauhan *et al*. (1993) [28]
Pre-emergence of pendimethalin at 0.50 kg/ha or fluchloralin at 0.50 kg/ha each followed by hand weeding at 30 DAS	Singh *et al*. (1999) [27]
Pre-emergence application of isoproturon at 0.75 kg/ha along with hand weeding at 25 DAS	Yadav (2004)
Pre-plant incorporation of fluchloralin at 1.0 kg/ha supplemented with one hand weeding at 40 days after sowing	Degra *et al*. (2006) [29]
Pre-plant incorporation of fluchloralin at 0.75 kg/ha followed by hand weeding at 30 days after sowing	Singh (2006) [14]
Pre-emergence application of isoproturon at 1.0 kg/ha along with interculture once at 30 DAS	Singh *et al*. (2009) [35]

Integrated effect of fertilizer and weed management practices

Angiras and Rana (1990) [31] produced considerably higher yield with a combination of hand weeding twice and 60 kg P2 05 /ha in an experiment on gobhi sarson (*Brassica napus*). However, at 40 kg P205/ha, it was statistically equivalent to a combination of 1.5 kg pendimethalin/ha (pre) and hand weeding twice. In medium phosphorus status acidic soils, 20 kg P205/ha might be saved. The highest level of management, which included a greater fertiliser dose and two weedings in an irrigated environment, resulted in considerably higher seed output in mustard than the medium and lower levels. The use of fertiliser to irrigated Indian mustard provided an ideal habitat for weed invasion, notably *Asphodelus tenuifolius*, *Chenopodium album*, and *Convolvulus arvensis* (Tomar and Namdeo, 1991) [3]. Singh (1992) [34] discovered that, while fertiliser treatment and weed control strategies both enhanced mustard seed production and yield attributes considerably, the interaction was not. Similarly, Bhadoria and Chauhan (1994) [18] discovered that whereas fertility considerably enhanced all growth and yield features and seed yield of mustard, weed control strategies significantly increased all metrics except primary branches and seeds/siliqua. Kaneria and Patel (1994, 1995) [19, 33] found that weed free > two hand weeding > pendimethalin + one hand weeding at 45 DAS > alachlor + one hand weeding at 45 DAS > alachlor alone produced the highest seed production in a research on weed and nitrogen control in mustard in Navsari, Gujarat. However, in terms of all yield characteristics, seed yield, and nitrogen absorption, the latter two treatments were shown to be superior than one interculture at 25 DAS or manual weeding at 45 DAS, interculture at 25 DAS + hand weeding at 45 DAS, and weedy check. Increasing nitrogen from 60 to 90 kg/ha enhanced all of these metrics as well as weed N, P, and K absorption, which is linked with greater weed biomass production. Dixit and Gautam (1995) [32] found a rise in weed population with an increase in fertility levels from 50% to 100% of the recommended dose while researching the interaction impact of management systems and weed control strategies in mustard at IARI, New Delhi. However, pendamethalin produced the best seed yield (21.92 q/ha) when grown with 100% fertiliser. Singh *et al*. (2009) [35] observed integrated weed management strategy with pre-emergence application of isoproturon at 1.0 kg/ha along with interculture once at 30 DAS under deep fertiliser placement method recorded the highest seed yield, proving its district superiority over other combinations of fertiliser and weed management practises while studying the effect of fertiliser placement and weed management practises in rainfed mustard at Varanasi.

Conclusion

Weed interference reduces mustard production significantly. Weed duration in the field affects yield, as do damage thresholds, which vary from weed to weed. To avoid economic losses, weed management should be implemented early in the growth cycle, particularly during the first four to six weeks of competition in mustard. Weed management is a system approach in which entire land use planning is done in advance to prevent weed invasion and offer crop plants a competitive advantage over weeds. Weed control in mustard has been achieved with pre-plant herbicide applications of fluchloralin and trifluralin. *Preemergence herbicides* with potential include alachlor, butachlor, isoproturon, metolachlor, metribuzin, nitrofen, oxadiargyl, oxadiazon, oxyfluorfen, pendimethalin, terbutryn, and thiobencarb. However, in the current setting, integrated weed management approaches are crucial since they are environmentally beneficial. In mustard crops, integrated management techniques incorporating preventative, cultural, and herbicidal treatments can offer an adequate level of weed control. The most successful and economically viable approach of weed management in mustard is the combination of chemical weed control and mechanical weeding.

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