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Impact of integrated weed management on growth and yield of mustard (*Brassica juncea* L.)

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Abstract
The field experiment was conducted during *rabi* 2021-22 at Agronomy farm, College of Agriculture, Dapoli, Dist. Ratnagiri (M.S.) to study the effect of integrated weed management practices on growth and yield of mustard (*Brassica juncea* L.). The experiment was laid out in in randomized block design with nine treatments and three replications. The treatments comprised of T_1: Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} (3 DAS), T_2: Quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha- (25-30 DAS), T_3: Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} (3 DAS) *fb* Quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25-30 DAS), T_4: Pendimethalin (PE) @ 1.0 kg a.i ha^{-1} + Hand hoeing (20 DAS) + Hand weeding (30-35 DAS), T_5: Quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25- 30 DAS) + Hand weeding (40-45 DAS), T_6: Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} + Straw mulch @ 5 t ha^{-1}, T_7: Quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25-30 DAS) + Straw mulch @ 5 t ha^{-1}, T_8: Hand hoeing (20-25 DAS) + Hand weeding (40-45 DAS) and T_9: Weedy check. The results revealed that significantly higher growth, yield attributes and yield of *rabi* mustard were recorded by Pendimethalin 30% EC (PE) @ 1.0 kg a.i. ha^{-1} + Hand hoeing (20 DAS) + Hand weeding (30-35 DAS) (T_4) over rest of the treatments.

Keywords: Mustard, integrated weed management, growth, yield

Introduction
Mustard (*Brassica juncea* (L.) Czern and ex. Coss.) is a major *rabi* oilseed crop of India. Among oilseeds, mustard occupies second position after soybean in India. The crop accounts for the one third of the total production of the oil seeds. During the fiscal year 2021-22 the total production of mustard in the country was 10.8 million metric tonnes from an acreage of 9.2 million hectares. It is estimated that at the end of fiscal year 2022, India will produce more than 11 million metric tons of rapeseed and mustard out of 35 million metric tons of oilseeds.
Weeds have become the major biotic stress in mustard cultivation. The potential yield losses due to weeds were accounted about 65 per cent depending on the crop, intensity of weed infestation, weed flora and adopted control practices (Yaduraju *et al*. 2006) [12]. Weeds caused up to 45 percent loss in the yield of mustard, they reduced the productivity and quality by competing with crop plants for available nutrients, water, land and light. Weed competition in mustard is more projected during early growth stages because crop growth is in low pace during the first 30 days after sowing. The critical period of crop weed competition in mustard is 15-40 DAS and, in this period, weeds cause about 25-50% of yield loss depending on weed flora present, stage and intensity of the crop growth (Yadav *et al*, 2017) [11] But, during later growth stages it has vigorous development and has smothering effect on weeds. Integrated weed management (IWM) 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. The majority of the IWM based research in India was herbicide based. Mainly in mustard the weeds are controlled by physical methods like hand weedings and chemical methods like use of pendimethalin, trifluralin and isoproturon as pre and post emergence (Gill and Singh, 2020) [11]. In mustard, integrated weed 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 integration of chemical weed control and mechanical weeding (Kumar and Barkha,

2022) [6]. Taking into consideration of these aspects the objectives was to study the effect of weed control practices on growth and yield of mustard.

Material and Methods

The field experiment was conducted at Agronomy farm, Department of Agronomy, College of Agriculture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra during the *rabi* 2021-22. The initial soil analysis of the experimental plot indicated that the experimental plot was sandy clay loam in texture, low in available nitrogen (278.08 kg ha^{-1}), medium in available phosphorus (11.80 kg ha^{-1}) and potassium (287.50 kg ha^{-1}), high in organic carbon (11.80 g kg^{-1}) and acidic in reaction (pH 6.09). The weekly mean minimum and maximum temperature during the crop growth period was 14.5 °C and 31.5 °C respectively. The variety used for the experiment was *Varuna* at seed rate of 4 kg ha^{-1} with spacing of 45 cm x 10 cm. The recommended dose of fertilizer (90:45:00 kg NPK ha^{-1}) was given with the supply of half the dose nitrogen and full dose of phosphorous at the time of sowing and remaining dose of N applied at 30 DAS. The herbicidal treatments were done using a knapsack sprayer with flat flan nozzle. The herbicides were applied with 600 l ha^{-1} of water. *Khurpi* was used for the hand hoeing practices. The experiment was laid out in in randomized block design with nine treatments and three replications. The treatments comprised of T_1: Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} (3 DAS), T_2: Quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha- (25-30 DAS), T_3: Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} (3 DAS) *fb* Quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25-30 DAS), T_4: Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} + Hand hoeing (20 DAS) + Hand weeding (30-35 DAS), T_5: Quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25- 30 DAS) + Hand weeding (40-45 DAS), T_6: Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} + Straw mulch @ 5 t ha^{-1}, T_7: Quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25-30 DAS) + Straw mulch @ 5 t ha^{-1}, T_8: Hand hoeing (20-25 DAS) + Hand weeding (40-45 DAS) and T_9: Weedy check. All the observations were recorded by following standard procedures.

Results and Discussion

Effect on growth

The data regarding the growth attributes of mustard like plant height (cm), number of branches plant^{-1}, dry matter plant^{-1} are represented in Table1.

The significantly taller plants were observed in the treatment of Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} + hand hoeing (20 DAS) + hand weeding (30-35 DAS) (T_4). The treatments hand hoeing (20-25 DAS) + hand weeding @ (40-45 DAS) (T_8) and quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25-30 DAS) + straw mulch @ 5 t ha^{-1} (T_7) were statistically on par with the treatment T_4. The comparative increase in plant height may be due to the lower weed competition and crop weed interference resulted by timely application of weed control measures, which in turn improved the nutrient and water uptake. Similar results were reported by Hadke *et al*. (2021) [3].

The significantly highest number of branches plant^{-1} in Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} + hand hoeing (20 DAS) + hand weeding (30-35 DAS) (T_4) followed by treatments of hand hoeing (20-25 DAS) + hand weeding @ (40-45 DAS) (T_8) and quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25-30 DAS) + straw mulch @ 5 t ha^{-1} (T_7) which were statistically on par with the treatment T_4. This may be due to the higher nutrient uptake as compared to the weedy check. The effect of pre-emergence application of herbicide followed by combination of hand weeding and hand hoeing had resulted in the weed free condition in the initial phases of crop growth which resulted in the more nutrient uptake by the crop and more the branching. Similar results were reported by Kalita *et al*. (2017) [4].

The significantly highest dry matter plant^{-1} was observed in the treatment of Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} + hand hoeing (20 DAS) + hand weeding (30-35 DAS) (T_4) which was on par with the treatments of hand hoeing (20-25 DAS) + hand weeding @ (40-45 DAS) (T_8) and quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25-30 DAS) + straw mulch @ 5 t ha^{-1} (T_7). Various weed management measures improved the uptake of nutrients by crops and the synthesis of growth regulators and hence dry matter production was higher in the combination of weed control measures compared to that of the lower nutrient uptake and reduced synthesis of growth regulators by plants in weedy check, which led to the reduction in dry matter production of mustard. Also, the improved morphological development attained due to lower competition for light, water and nutrients had led to increased photosynthetic rate which might have improved the dry matter production. Similar results were revealed experimentally by Raj *et al*. (2022) [8].

Table 1: Effect of integrated weed management practices on growth of mustard

Treatments	Plant height (cm)	No of branches plant^{-1}	Dry matter plant^{-1} (g)
T_1	166.72	4.51	19.25
T_2	166.47	4.48	19.19
T_3	168.10	4.66	19.29
T_4	172.43	5.56	19.61
T_5	169.18	5.17	18.97
T_6	168.40	5.21	18.70
T_7	170.91	5.50	19.38
T_8	171.02	5.51	19.45
T_9	164.58	4.29	18.27
S.Em. (±)	0.68	0.024	0.102
C.D. at 5%	2.04	0.072	0.306

Effect on yield attributes and yield

The data regarding the impact of integrated weed management on yield attributes and yield of mustard is represented on Table 2.

The seed, straw and biological yield (kg ha^{-1}) as influenced by various integrated weed management measures are represented on graph 1.

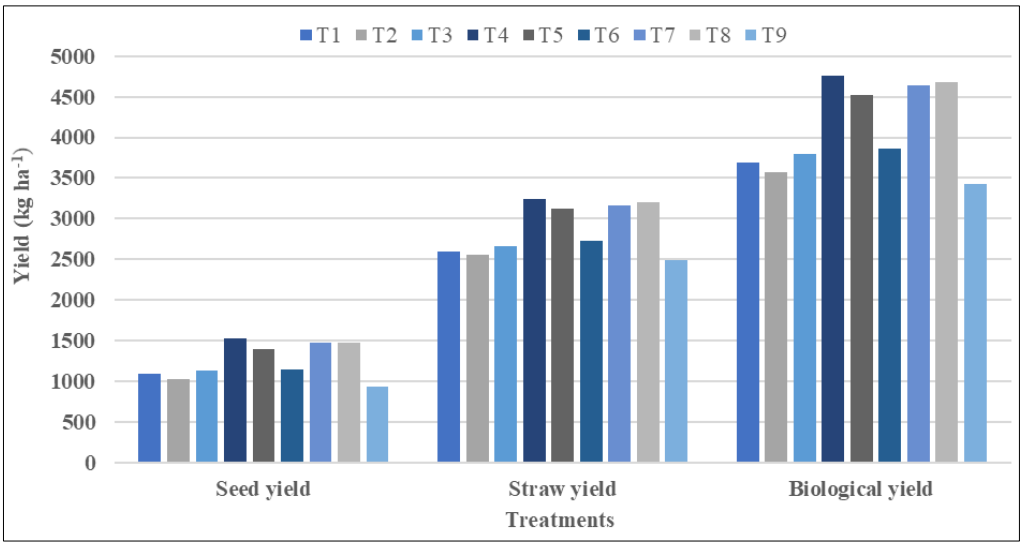
The significantly highest number of siliquae plant^{-1} (164.56), and highest number of seeds siliquae^{-1} (13.20) was observed in the treatment of Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} + hand hoeing (20 DAS) + hand weeding (30-35 DAS) (T_4) which was followed by the statistically at par treatments of hand hoeing (20-25 DAS) + hand weeding @ (40-45 DAS) (T_8) and quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25-30 DAS) + straw mulch @ 5 t ha^{-1} (T_7). The highest number of siliquae plant^{-1} may be due to the control of weeds effectively with the pre-emergence application of herbicides supplemented by hand hoeing and hand weeding timely which made the plot weed free and the uptake of more nutrients and water helped in the better growth and development of

mustard. The test weight of the seeds was not significantly affected by the weed control measures. Similar results were revealed by Kumar *et al.* (2012).

The highest seed yield, straw yield, biological yield and harvest index was obtained in the treatment of Pendimethalin 30% EC (PE) @ 1.0 kg a.i ha^{-1} + hand hoeing + hand weeding (30-35 DAS) (T_4). The following treatments were hand hoeing (20-25 DAS) + hand weeding @ (40-45 DAS) (T_8) and quizalofop-p-ethyl 5% EC (PoE) @ 0.06 kg a.i ha^{-1} (25-30 DAS) + straw mulch @ 5 t ha^{-1} (T_7) which were statistically on par with the treatment T_4. The overall productivity of a crop is the function of coordinated interaction of the growth and yield parameters of the crop. The various measures of weed control had a significant impact on the seed yield, straw yield, biological yield and harvest index. This might be due to the abatement of weed competition and the knockdown effect of weeds due to the precise and accurate application of the herbicide in integration with mechanical methods of hand weeding and hand hoeing. These methods provided an optimum condition for the vigorous vegetative growth and the photosynthesis rate of the crop which in case improved yield attributes. Further the practice of hand hoeing had provided a loosened soil or tilth condition in the initial growth phase which provided the proper soil aeration, soil water retention as well as proper root penetration and root development. This in turn accelerated the uptake of nutrients and water even from the deeper layers of the soil. This may have boosted the growth vigour of mustard crop and the yield optima were reached. The hand weeding practiced after proper interval had a knockdown impact on weeds providing nearly weed free condition in the flowering and fruiting stage of plant. During the critical period of crop development weeds were under control which resulted in the tremendous yield difference in comparison with the weedy check about 38.5% lesser yield. The biological yield of the best treatment was 28.4% higher over the weedy check. The results were in close proximity with the conclusions of Mukherjee (2014) [7], Gupta *et al.* (2018) [2] and Singh *et al.* (2020) [9].

Table 2: Effect of integrated weed management practices on yield attributes and yield of mustard

Treatments	No. of siliquae plant^{-1}	No. of seeds siliquae^{-1}	Test weight (g)	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1	150.27	11.80	4.60	1096.49	2594.97	3690.46	29.72
T_2	144.33	11.06	4.42	1019.80	2557.55	3577.51	28.51
T_3	151.04	11.95	4.84	1130.33	2661.33	3791.66	29.81
T_4	164.56	13.20	5.46	1521.00	3237.67	4758.67	31.96
T_5	152.93	12.35	4.81	1400.33	3122.33	4522.66	30.96
T_6	152.16	12.21	4.71	1151.14	2724.10	3867.49	29.77
T_7	162.51	12.77	5.28	1468.67	3167.67	4636.34	31.68
T_8	162.86	12.92	5.33	1474.67	3199.00	4673.67	31.55
T_9	139.18	10.92	4.35	939.67	2493.23	3432.17	27.37
S.Em. (±)	1.62	0.16	0.04	39.63	39.44	66.21	….
C.D. at 5%	4.87	0.47	NS	118.83	115.33	198.65	….



Graph 1: Seed yield, Straw yield and biological yield as influenced by weed control measures

Conclusion

It is concluded that the best option for integrated weed management in the Konkan region will be pre-emergence application of Pendimethalin 30% EC @ 1.0 kg a.i ha^{-1} followed by hand hoeing at 20 DAS and hand weeding at 25-30 DAS for effective control of weeds and for obtaining the better growth and higher yield in *rabi* mustard.

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