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Integrated weed management in *Kharif* sunflower (*Helianthus annuus* L.)

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Abstract
The field study on integrated weed management in kharif sunflower was carried out at the Experimental Farm, Agronomy Section, Oilseeds Research Station, Latur, during the 2022–2023 kharif season. With three replications and eight treatments, the experiment was set up in a randomised block design. T_1 stands for weed-free, T_2 for weedy check, T_3 for farmer's practices (1 HW+ 1HH), T_4 for pendimethalin 30 EC at 0.75 kg a.i. ha^{-1} + hoeing, T_5 for pendimethalin 30 EC @ 1.0 kg g a.i. ha^{-1} + straw mulching, T_6 for metolachlor 50 EC at 0.75 a.i. ha^{-1} + hoeing, T_7 for metolachlor 50 EC @ 1.0 a.i. ha^{-1} + straw mulching, and T_8 for sunflower + green gram intercropping. The gross and net plot sizes of the experimental unit were 5.4 m × 4.5 m and 4.2 m x 3.9 m, respectively. On July 16, 2022, seeds were sown using the dibbling method at a spacing of 60 x 30 cm2 with a seed rate of 5 kg ha^{-1}. 90:45:45 kg ha^{-1} of fertiliser, the recommended dosage, was applied. N administered in divided doses and the entire amount of PK administered as a baseline dose. October 15, 2022, was the harvest date of the crop. The outcome shown that the application of Pendimethalin 30 EC @ 1.0 kg g a.i. ha^{-1} + straw mulching and Metolachlor 50 EC @ 1.1 a.i. ha^{-1} + straw mulching considerably increased the growth yield contributing features. Were discovered to be advantageous as compared to the other treatments.

Keywords: Sunflower, metolachlor, pendimethalin, intercropping, straw mulching

Introduction
The sunflower, or *Helianthus annuus* L., is a significant oilseed and decorative crop that is mostly grown in India. With over 264 species in the Helianthus genus, it is one of the most widely grown oilseed crops in the Asteraceae family and a significant source of vegetable oil. The Greek words "Helios" (meaning sun) and "Athos" (meaning flower) are the origin of the word sunflower. Sunflower is commonly referred to as "Surajmukhi." Although sunflower is a temperate crop, it can withstand both extreme heat and cold. Sunflowers are thought to have originated in Mexico and the southern United States. It was first brought to India in 1969, and commercial growing got underway in 1972–1973. The world's leading producers of sunflowers include Argentina, Bulgaria, USSR, Turkey, USA, Romania, South America, France, Spain, and India. 30–35% carbs, 14–19% protein, 21-27% hull, 7-9% soluble sugar, and 35–42% oil are all present in sunflower seeds. Sunflower oil is recommended or beneficial for heart patients because of its abundant supply of linoleic acid (64%) which dissolves cholesterol buildup in the heart's coronary arteries. Sunflowers are a good source of vitamins A, D, E, and B complex, as well as enough calcium and iron. Oleic acid makes about 20% of their content. Other uses for sunflower oil include the production of soap and cosmetics. In addition to being a key component of several margarine and shortening products, sunflower oil is used in cooking. Sunflower oil cake, which is fed to cattle and poultry, has a high protein content of 40–44%. Grown in kharif, sunflower is a significant oilseed crop. and the rabi seasons in every state. Russia, Ukraine, Argentina, China, France, USA, Spain, and India are the main producers of sunflowers. The world's sunflower crop covers 29.53 million hectares, with a yield of 1970.3 kg ha and a production of 58.18 MT! (Unidentified, 2021 LA). In 2020–21, sunflower agriculture will occupy 0.22 million hectares in India, yielding 0.23 million metric tonnes and 1023 kg ha' of productivity. With 0.11 MT of production, Karnataka leads all other Indian states in sunflower production, followed by 0.02 MT from Odisha and 0.02 MT from Haryana. In Maharashtra, 26,000 hectares of sunflower are produced, yielding 12,200 tonnes of output and 467.8 kg ha of productivity. significant sunflower cultivation The districts of Nanded, Aurangabad, Latur, Osmanabad, and Solapur are in Maharashtra. In the Latur district, sunflower is planted on 711 hectares of land, yielding 426 tonnes of output and 598.75 kg of productivity per hectare.

Decreased sunflower seed yield by up to 55%. The districts of Nanded, Aurangabad, Latur, Osmanabad, and Solapur are in Maharashtra. In the Latur district, sunflower is planted on 711 hectares of land, yielding 426 tonnes of output and 598.75 kg of productivity per hectare. Decreased sunflower seed yield by up to 55%.

One of the biological barriers to achieving increased sunflower yield through wider spacing and higher fertiliser doses is weed competition. One of the main causes of the low sunflower yield is heavy weed infestation. Unchecked weed development decreased sunflower seed output by as much as 55%. Herbicide resistance develops in weeds with extended, continuous use, making weed management more challenging. Major weeds can be effectively controlled with herbicides combined with mechanical and cultural weeding. Therefore, it's essential to combine the environmentally and financially sustainable cultural, chemical, and mechanical methods of weed management. This context informed the current investigation. Utilising all available weed control techniques-preventive measures, monitoring, crop rotation, tillage, crop competition, mechanical and physical control, herbicide rotation, herbicide mixtures, biological control, nutrition, irrigation, flaming, etc.-integrated weed management (IWM) is a sustainable approach to managing weeds in a way that minimises risks to the economy, public health, and the environment. The importance of integrated weed control is growing as a means of reducing losses and increasing input usage efficiency.

Materials and Methods

At the Experimental Farm, Agronomy Section, Oilseeds Research Station, Latur, an agronomic analysis was conducted to ascertain the integrated weed management in kharif sunflower (*Helianthus annuus* L.) during the Kharif season of 2022–2023. The experimental field's soil was uniformly flat, medium in depth, and black in colour. The soil exhibited optimal water-holding capacity and efficient drainage. According to the chemical composition of the experimental field, the soil had a high potassium concentration (580 kg ha^{-1}) and a very low phosphorus content (8.57 kg ha^{-1}) It also had a low nitrogen level (231 kg ha^{-1}). The soil's electrical conductivity (Ec 0.25 dSm-and neutral reaction (pH 7.02) were discovered. Eight treatments, three replications, and a randomised block design were used in the setup of the experiment. T_1-Weed free treatments are used. T_2: weed inspection; T_3: farmer's practices (1 HW+ 1HH); T_4: pendimethalin 30 EC 0.7 kg a.i. ha^{-1} + hoeing; T_5: pendimethalin 30 EC @ 1.0 kg g a.i. ha^{-1} + straw mulching; T6: metolachlor 50 EC @ 0.75% a.i. ha^{-1} + hoeing; T_7: metolachlor 50 EC @ 1.0 a.i. ha^{-1} + straw mulching; and T_8: sunflower + green gram intercropping. The gross and net plot sizes, which were split into 5.4 m × 4.5 m and 4.2 m x 3.9 m, respectively, made up the experimental unit. On July 16, 2022, seeds were sown using the dibbling method at a spacing of 60 x 30 cm with a seed rate of 5 kg ha^{-1}. 90:45:45 kg ha^{-1} of fertiliser, the recommended dosage, was applied. N administered in divided doses and the entire amount of PK administered as a baseline dose. October 15, 2022, was the harvest date of the crop.

Results and Discussion growth attributes

Throughout the whole crop growth cycle, up until crop maturity, plant height and total dry matter rose. Due to leaf ageing, the number of functional leaves and leaf area grew until 60 DAS and then declined as the leaves matured. Up until maturity, the head diameter was likewise expanded. Due to the stem's shrinkage, the stem girth decreased slightly as it approached harvest and then increased to 75 DAS. Plant height (206.60 cm), number of functional leaves (23.38), leaf area (60.40 dm2), total dry matter (132.01 g), stem girth (9.95 cm), and head diameter (18.39 cm) were all significantly higher in the weed-free treatment (T_1), and these results were closely followed by the application of Pendimethalin 30 EC @ 1.0 kg a.i ha^{-1}+ straw mulching (T_5). and Straw mulching (T_7) treated with metolachlor 50 EC @ 1.0 kg a.i ha^{-1} was found to be significantly better than the other treatments. With respect to plant height, absolute growth rate, relative growth rate, and leaf area index, the weed-free treatment (T_1) demonstrated the highest values. This was closely followed by the application of Pendimethalin 30 EC @ 1.0 kg a.i ha^{-1}+ straw mulching (T_5), and Metolachlor 50 EC @ 1.0 kg a.i ha^{-1}+ straw mulching (T_7), which were found to be significantly superior to the other treatments. Lower values were seen in the weedy check treatment (T_2).

Yield attributes

The weed-free treatment (T_1) had the highest test weight and seed yield $plant^{-1}$, harvest index (27.71%), number of filled seeds $plant^{-1}$, seed yield (1973 kg ha^{-1}), stalk yield (5149 kg ha^{-1}), biological yield (7122 kg ha^{-1}) and harvest index (27.71%). These treatments were found to be significantly superior to the other treatments when Pendimethalin 30 EC @ 1.0 kg a.i ha^{-1}+ and Metolachlor 50 EC @ 1.0 kg a.i ha^{-1}+ were applied. Lower values were seen in the weedy check treatment (T_2) for the parameters stated above.

Conclusion

The study found that the weed-free treatment (T_1) produced the best growth features, seed yield, weed control efficiency, and lowest weed index. The weed-free treatment (T_1) yielded the highest net monetary returns (₹ 73610 ha^{-1}), but the application of Pendimethalin 30 EC @ 1.0 kg a.i ha^{-1}+ straw mulching recorded the highest benefit: cost ratio (2.72). This was closely followed by the application of Pendimethalin 30 EC @ 0.75 kg a.i ha^{-1}+ hoeing (T_4) and Metolachlor 50 EC @ 1.0 kg a.i ha^{-1}+ straw mulching (T_7).

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