Impact Of Weed Control Techniques on Weeds, Yield, and Quality Attributes of Field Pea *(Pisum Sativum* Var. Arvense)

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Weed control techniques significantly influence the weed flora by reducing weed density and biomass, while enhancing the yield and improving the quality attributes of field pea (*Pisum sativum*) through better resource utilization and reduced crop-weed competition. The objective of this study was to assess how different weed control techniques affected weed suppression, and yield-contributing parameters of field pea. Ten treatments, each with three replications, were used in the field research, which was carried out using a randomized complete block (RCB) design. Various weed control methods were used in the treatments, including mulches (Eucalyptus leaves, weed biomass, and poplar leaves), herbicides (S-metolachlor @ 1 L ha^{-1}, Pendimethalin @ 2.5 L ha^{-1}, Haloxyfop-p-methyl @ 0.9 L ha^{-1}, and Quizalofop-p-ethyl @ 2.0 L ha^{-1}), two hand weeding at 30 and 60 DAS (days after sowing), a weed-free check, and control (untreated) treatment. Plant height (cm), pod length (cm), days to 50% flowering, days to 50% pod formation, and pod yield (kg ha^{-1}) were among the agronomic traits, that were assessed. The findings demonstrated that the yield components of peas were strongly impacted by weed control techniques. The weedy check had the longest periods for 50% flowering (89 days) and 50% pod formation (110 days), whereas the weed-free treatment had the lowest time duration for both parameters. The weed-free check (73.83 cm) and two-hand weeding (70.40 cm) treatments produced the highest plants, and longest pods, followed by the applications of Pendimethalin and S-metolachlor. Similarly, when compared to other treatments, the pod yield was considerably increased by the weed-free check (5424 kg ha^{-1}), two-hand weeding (5278 kg ha^{-1}), and Pendimethalin (5020 kg ha^{-1}) treatments. The study concluded that the best methods for lowering weed competition and improving yield-contributing parameters in pea cultivation are two-hand weeding or the application of Pendimethalin and S-metolachlor.

Keywords: Chemicals, Mulches, Pea, Pod yield, Weed management

Introduction: Vegetables lie amongst the most essential crops grown across various climatic conditions [1]. In Pakistan, over thirty different types of vegetables are grown throughout the year,

including both summer and winter crops [2][3]. Unlike cereal crops, vegetables can be grown on small areas of land, providing substantial yield, economic returns, and nutritious significance [4][5]. Among these, the field pea (*Pisum sativum var. arvense*), an annual herbaceous crop from the Fabaceae family, thrives particularly well in colder climates [6]. Recognized for its high nutritional content, peas dried grains have a protein level of 24%, which is considerably higher than the 9% protein content found in wheat grains [7][8]. Almost 17,406 hectares of peas are grown in Pakistan, producing 114,925 tonnes of grain annually [9]. A total of 13,418 tonnes are produced on 1,942 hectares of cultivation in Khyber Pakhtunkhwa province [10]. The low pea yield is caused by several causes, such as the adoption of inferior cultivars, antiquated farming methods, and unfavorable weather conditions. However, the main cause of decreased production is still weed competition. Heavy weed infestations can have an insignificant impact on the crop's final output if they are managed early before they compete with it [11][12]. According to Jilani et al. [13] and Mehmood et al., [14], weeds are unwanted plants that compete with crops for essential resources, lowering yields and producing lower-quality products. Weed infestations cause 39% to 89% of Pakistan's pea crop to be lost. According to Brijbhooshan et al. [15] and Sajid et al., [16], the slow initial growth of peas, combined with their wide row spacing, creates favorable conditions for weed competition and proliferation. The goal of good weed control is to increase the crop's capacity to outcompete weeds [17][18]. In pea production, a variety of weed control techniques are used, such as chemical, mechanical, and cultural methods. For weed suppression, mulching is the most successful cultural practice. In addition to controlling weeds in pea crops, mulching improves soil structure, controls temperature, and retains moisture. It stabilizes soil temperature in the top 20 to 30 cm layer, which is particularly important for Kharif vegetable crops in Pakistan's arid regions [19][20]. Weed density can be effectively reduced through mechanical weed control methods such as hand weeding and hoeing [21][22][23]. Plots that underwent continuous hand weeding throughout the growing season to suppress weed growth have demonstrated enhanced pod yield [24][25]. Because of its speed, effectiveness, and affordability, chemical weed control is frequently chosen over mechanical and cultural approaches [26][27]. Hand weeding or using animal-drawn tools is effective but can be expensive due to high labor, and cost of energy. Herbicides offer land managers a more affordable, and competent option for weed control [28][29]. In cases of severe weed infestations, the judicious practice of herbicides has become crucial for effective weed management [30][31]. This study was designed to examine the impact of different control treatments on weeds and yield traits of field peas. This study uniquely compares a diverse range of weed control strategies, including organic mulches, selective herbicides, and manual weeding, under a randomized complete block design to determine their comparative effectiveness on weed suppression, yield components, and phonological development of field pea. It provides comprehensive insights into how these practices influence both the biological and economic performance of pea cultivation, offering practical recommendations for sustainable weed management in pulse-based cropping systems.

Materials and Methods:

Layout and Locality:

An experiment was carried out at the Horticulture Research Farm of the University of Agriculture, Peshawar, to assess the effects of different weed management practices on pea cultivation. In November 2022, the hybrid variety recognized as "Climax" was manually seeded. A well-prepared seedbed was created by leveling the soil with a plank after it had been plowed twice using a cultivator. In the experimental field, ridges were formed after preparing the land, and the pea variety was sown on these ridges. Each plot consisted of three ridges, each measuring three meters in length, with a spacing of sixty centimeters between ridges and fifteen centimeters between plants. Urea and Muriate of Potash (MOP) were applied to deliver the appropriate fertilizer rates of N-40, P-90, and K-90 kg ha^{-1} for each treatment. The experimental treatments comprised T1 (mulching with eucalyptus leaves at 20 DAS), T2 (mulching with weed biomass at 20 DAS), T3 (mulching with poplar leaves at 20 DAS), T4 (S-metolachlor at 1 L ha^{-1} applied at 1 DAS), T5 (Pendimethalin at 2.5 L ha^{-1} applied at 1 DAS), T6 (Haloxyfop-p-methyl at 0.9 L ha^{-1} applied at 20 DAS), T7 (Quizalofop-p-ethyl at 75 mL ha^{-1} applied at 20 DAS), T8 (two hands weeding at 30 and 60 DAS), T9 (weed-free check), and T10 (weedy check as control). Key parameters measured during the study included

days to 50% flowering, days to 50% pod formation, plant height (cm), pod length (cm), and pod yield (kg ha^{-1}).

Statistical Analysis:

The data collected for various parameters were analyzed individually using the ANOVA technique with the Statistics 8.1 software [32].

Results and Discussions:

Days to 50% Flowering:

There were significant distinctions in how different control methods, affected the number of days before 50% flowering. Table 1 shows that the weedy check (control) treatment exhibited the longest duration to 50% flowering (89 days), followed by the Quizalofop-p-ethyl treatment (80.66 days). These two treatments were statistically different from one another. In contrast, the weed-free treatment achieved 50% flowering (64.66 days) in the shortest period, and the treatment that involved two hands weeding at 30 and 60 DAS (66.66 days), followed in subsequent. Treatments containing eucalyptus, and poplar leaves mulch exhibited longer durations to 50% flowering likened to herbicide-treated plots. The results demonstrated that while the weedy check exhibited delayed 50% flowering, earlier flowering was observed in the weed-free treatment, two-hand weeding, and herbicidal treatments (Pendimethalin and S-metolachlor). These outcomes are dependable, with those of [33][34], who stated that weed check treatments had longer times to 50% flowering. Additionally, our outcomes are matched, with those of Ayub et al., [35]**,** who revealed that mulching reduced flowering days.

Days to 50% Pod Formation:

According to the analysis of variance, the number of days needed for 50 % pod development was found to be intensely impacted by the various weed control techniques. Table 1 exhibited that the weedy check (110 days) plot took the longest days to reach 50% pod production, followed by the haloxyfop-p-methyl (105.33 days) treatment. In contrast, the fastest time to 50% pod formation was attained by the weed-free (82.33 days) treatment and the two-hand weeding at 30 and 60 DAS (84.33 days). Weed density was successfully reduced by twice hand weeding (30 and 60 DAS), however herbicidal treatments also encouraged early pod improvement. Moreover, the time to 50% pod development was reduced with comparatively suitable results, when poplar and eucalyptus leaves were used as mulch. The results indicated that the best methods for decreasing the duration to 50% pod development in peas are weed-free treatment, and twice-hand weeding [36][37]. Poplar and eucalyptus leaf mulches are another practical way to increase the timing of pod formation [38].

Plant Height (cm):

Statistical analysis of the data in Table 1 revealed that the tallest plants were recorded in the weed-free treatment (73.83 cm), followed by plots hand-weeded twice at 30 and 60 DAS (70.40 cm), and chemically treated plots with Pendimethalin (67.20 cm) and S-metolachlor (63.86 cm). On the other hand, the weedy check (48.20 cm) plot had the smallest plants, which was statistically distinct from all other treatments. Poplar, and eucalyptus leaves used as mulch produced plant heights of 58.26 cm and 60.53 cm, respectively. According to the research, herbicides such as S-metolachlor, and Pendimethalin effectively inhibited weeds and encouraged plant improvement, which led to taller field pea plants. The struggle for light, space, and nutrients, in the weedy check plots to be reduced, thinner, and weaker. To suppress weeds, and increase plant height, [39][40] recommended the prudent application of herbicides, which these data support.

Pods Length (cm): Table 1 showed that the weed-free check (8.40 cm) and the twice-hand-weeded plot at 30 and 60 DAS (7.40 cm) yielded the largest pod length, in comparison to all other treatments. After these were plots treated with S-metolachlor (6.36 cm), and Pendimethalin (6.76 cm). Eucalyptus leaves mulch produced pods, that were (6.03 cm) long. Alternatively, the shortest pods were produced by the hand-weeded plot at 20 DAS (5.36 cm),

and the weedy check (5.03 cm), which were statistically distinct from one another. Our data exhibited that weed control and pod length were greatly impacted by herbicides in field peas, while mulched treatments produced similar outcomes. Increased nutrient availability for pea plants, higher soil moisture retention, less intra-specific opposition, and unfavorable ecological conditions, could all be responsible for the declined weed population. These results are in close agreement with the outcomes of Hussain et al. [41] and Iqbal et al., [42] who found that herbicide applications, and two weeding treatments (30 and 60 DAS), considerably increased pod length, and inhibited weed enlargement.

Pod Yield (kg ha^{-1}):

The data in Table 1 indicated that the weed-free check (5424 kg ha^{-1}), and the twice hand-weeded at 30 and 60 DAS (5278 kg ha^{-1}) treatment yielded the greatest pod yields. Followed by chemical treatments of Pendimethalin and S-metolachlor resulted in yields of 5020 and 4803 kg ha^{-1}, respectively, which were statistically comparable. Whereas, the control treatment yielded the smallest pods (1888 kg ha^{-1}). Our results showed that a variety of weed control techniques, such as mechanical, chemical, and cultural methods, importantly boosted pea pod output, while effectively suppressing weeds. Due to severe competition between weeds, and pea plants for nutrients, the twice hand-weeded treatment produced the maximum yield, whereas the control plot produced the lowest. These outcomes are in line, with those of Noor et al. [43] and Shahzad et al., [44]**,** who reported that hand weeding twice, and the use of S-metolachlor, and Pendimethalin herbicides significantly increased pod yields.

Table 1 Impact of various control techniques on days to 50% flowering, days to 50% pod formation, plant height (cm), pod length (cm), and pod yield (kgha^{-1}) in field pea.

Treatments	Days to 50 % flowering	Days to 50 %pod formation	Plant height (cm)	Pods length (cm)	Pod yield (kg ha^{-1})
Eucalyptus leaves as mulch	74.66 h	94.67 h	60.53 de	6.03 e	4051 d
Weed biomass as mulch	78.66 f	98.67 f	55.63 efg	5.36 g	3677 e
Poplar leaves as mulch	73.33 g	96.67 e	58.26def	6.00 of	3780e
S-metolachlor	73.00 i	92.67 i	63.86 cd	6.36 d	4803 bc
Pendimethalin	69.66 j	87.67 j	67.30 bc	6.76 c	5020 b
Haloxyfop-p-methyl	79.33 of	100.67 d	60.80 de	5.43 g	4664 c
Quizalofop-p-ethyl	80.66 de	99.33 e	60.56 de	5.56 g	4173 d
Two-hand weeding (30 and 60DAS)	66.66 k	84.33 k	70.40 ab	7.40 b	5278 a
Weed-free check	64.66 l	82.33 l	73.83 a	8.40 a	5424 a
Weedy check (Control)	89.00 a	110.00 a	48.20 h	5.03 h	1888 i
LSD $_{(0.05\%)}$	1.33	0.58	4.77	0.18	248

Conclusion:

According to our research, various weed control practices used had a significant influence on the weed population, plant development, and yield components of field peas. The use of Pendimethalin, S-metolachlor herbicides, and twice-hand weeding was the most efficient method among the others in lowering the density of weeds, which improved pea production, and its attributes dynamics.

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