

Estimation of Critical Period for Weed Control in Field Pea (*Pisum sativum* L.) Under Different Seeding Rates

R. A. Mousa¹, Kh. A. Abou-Zied¹ and May H. M. Elattar¹

ABSTRACT

An experiment was carried out at EL-Serw Agricultural Research Station, Agricultural Research Center, at Damietta Governorate, Egypt during 2018/19 and 2019/20 winter seasons to estimate the critical period of field pea/weed competition under two seeding rates. The experiment included 20 treatments which were the combination of two seeding rates (25 and 35 kg seeds/fed.) and 10 weed competition treatments which were weed-free period at 2, 4, 6 and 8 weeks after sowing (WAS) as well as whole season weed free, and weed competition treatments at 2, 4, 6 and 8 weeks after sowing (WAS) as well as whole season-weed competition. The experimental design was a split-plot design where the two seeding rates were allocated to the main plot and the weed competition treatments were allocated to the sub-plots.

Results indicated that increasing seeding rate from 25 kg seeds/ fed. up to 35 kg seeds/fed decreased significantly broad-leaved, grass and total annual weeds dry weight in both seasons, while it increased plant height, green pods yield and dry seed yield by 7.08, 13.18 and 15.73%, in the first season, and 10.09, 13.07 and 11.22%, in the second season, respectively, compared with 25 kg seeds/fed. However, the number of branches/plant, number of pods/plant, pods' weight/ plant, number of seeds/ pod and 100 seeds weight were significantly decreased. Increasing the period of early weed competition more than two weeks and/or decreasing the late weed competition to more than 6 weeks can decrease significantly the seed yield. Results indicated that the interaction between seeding rates and weed removal periods was significant in both seasons in their effect on all weed categories. Whole season weed free and seeding rate 35 kg seeds/fed. gave the highest reduction in all weed categories dry weight and gave the highest green pods and dry seed yields in both seasons.

The critical period of field pea-weed competition was 2-6 weeks after sowing under seeding rate of 25 kg seeds/fed. and 3-6 weeks after sowing under seeding rate of 35 kg seeds/fed.

Keyword: field pea, *Pisum sativum*, seeding rate, weed competition, critical period

INTRODUCTION

Field pea (*Pisum sativum* L.) crop suffers strongly from weed competition; which necessitates the determination of the critical period for weed control (CPWC) as part of overall integrated weed management strategy so that weed control measures can be targeted during this period to avoid weed competition to the

crop. The CPWC is defined as the critical key period during which weed competition with a pea's crop is maximum and must be controlled to avoid yield losses. The knowledge of CPWC would be useful in improving weed control by targeting weed control measures at right time (herbicide application and all weed control methods). Many researchers estimated the field pea yield losses due to the presence of weed competition. It was found that the field pea yield losses due to weed competition to be between 45-77% of green pods yield. That might be due to the slow initial growth of field pea, and the wide spacing's that provide congenial environment for weeds to grow and compete with crop. The losses in field pea yield due weed competition differs according to the weed species and density, and is correlated negatively and significantly with field pea dry seed yield and its components (Blackshaw, 1998; Dimitrova, 1998; Tripathi *et al.*, 2001; Fakkar and El-Dakkak, 2015). At the time of weed emergence, weed species which have more competitive ability than the crop and the period of weed-crop competition plays an important role on the rate of crop losses. Field pea weed competition starts in early stages. Under the high infestation and early emergence of weeds, the early competition may begin after 1-2 weeks after sowing. Harker *et al.* (2001) and other researchers pointed that the critical period of field pea/weed competition was between 20-70 days after sowing to achieve 95% of field pea weed-free yield. Similar findings were reported by Kumar *et al.* (2009) and Mainpal *et al.* (2016). Increasing seeding rate of field pea is considered one of the elements of integrated weed management. Some researchers studied the application of the integration between increasing seeding rate and weed removal or weed competition treatments to reduce the weed competition and improve growth characters, yield and yield components of field pea. The increase of field pea seeding rate increased the number of plants/unit area and decreased the number and dry weight of weed plants/unit area and increased the ability of field pea to compete with weed populations (Wall *et al.*, 1991; Townley- Smith and Wright, 1994; Grevsen, 2003).

Therefore, the present study was undertaken to determine the critical period for weed control in field

pea to render weed management more effective and economical under two seeding rates.

MATERIAL AND METHODS

Two field experiments were conducted during 2018/19 and 2019/20 winter seasons at EL-Serw Agricultural Research Station, Agricultural Research Center, in Damietta Governorate, Egypt, to determine the critical period of weed competition on field pea under two seeding rates. The soil types of this study were of clay texture with 16.12 and 16.42% sand, 21.42 and 19.79% silt and 62.46 and 63.79% clay, pH was 7.7 and 7.5 with organic matter of 1.21 and 1.46% in 2018/2019 and 2019/2020 seasons, respectively.

The experimental design was randomized complete block design with four replicates and the treatments were arranged in a split-plot arrangement where the two seeding rates, 25 and 35 kg/fed., were allocated in the main plots and ten weed removal treatments were assigned to the sub plots as follows:

A. Main plots: seeding rates

- 1- 25 kg seeds/fed.
- 2- 35 kg seeds/fed.

B. Sub plots: Weed removal treatments:

1. Weed free for 2 weeks after field pea sowing.
2. Weed free for 4 weeks after field pea sowing.
3. Weed free for 6 weeks after field pea sowing.
4. Weed free for 8 weeks after field pea sowing.
5. Weed free for whole season.
6. Weedy up to 2 weeks after field pea sowing.
7. Weedy up to 4 weeks after field pea sowing.
8. Weedy up to 6 weeks after field pea sowing.
9. Weedy up to 8 weeks after field pea sowing.
10. Weedy for whole season.

The experimental fields were prepared through two plowings, harrowing and leveling. Calcium superphosphate (15.5% P₂O₅) was added at the rate of 200 kg/feddan before soil plowing. The size of sub plot was 21m² (4.2 m width x5m long) and each plot contained 6 rows. Peas seeds (*Pisum sativum* L., cv. Master-B) were planted at the two rates on the 25th and 20th of October, while green pods were harvested on the 28th and 26th of January, and dry peas were harvested on the 2nd and 6th of March in 2018/19 and 2019/20 winter seasons, respectively.

Recorded characters:

1- Weed assessment

Assessments of biomass were performed at each time of removal on samples collected from 1 m² in the two central rows of each plot before weed removal in early competition and before harvest in late competition. At each assessment, weeds were hand pulled then identified according to Täckholm (1974) into species and classified into annual grass, broad-leaved and total weeds. Weed samples were air-dried and then dried in an electric oven at 65-70°C till constant weight was achieved.

2- Peas growth characters, yield and yield components:

At green-maturity: a sample of ten pea plants were collected randomly from the central lines of each plot and used to measure the following characters: plant height (cm) measured from the cotyledonary node to the top of the main stem., number of branches/plants, number of pods/plants, number of seeds/pod, weight of pods (g/plant) and green pods yield (ton/fed.), while, 100-seed weight (g) and dry seed yield (ton/fed.) were recorded at dry harvest date.

3- Statistical analysis:

Data of each season were statistically analyzed according to the procedures outlined by Gomez and Gomez (1984) and the means were compared by least significant differences (L.S.D. at 5 %).

RESULTS AND DISCUSSION

1- The effects of seeding rates:

a. Weeds dry weight (g/m²):

It was noticed that the experimental location in the two seasons was moderately infested by both grass and broadleaf weeds species. The weed species included *Melilotus indica*, *Rumex dentatus*, *Beta vulgaris* and *Cichorium pumilum* as annual broad-leaved weeds and *Phalaris minor* as annual grass weed, with an infestation rate of 268.5 and 257.1 (g/m²) in the first and second seasons, respectively.

Data on Table 1 showed that seeding rates had significant effects on weeds dry weight (g/m²) in both seasons.

Increasing the seeding rate from 25 to 35 kg/fed. caused reduction percentages in the broadleaf weeds, grass weeds and the total annual weeds by 11.12, 12.94 and 11.71 in the first season, and 17.84, 10.02 and 15.49% in the second season, respectively. These results are in line with those obtained by Wall *et al.* (1991) and Grevsen (2003).

Table 1. The effect of seeding rates on dry weight of grass, broad-leaved and total annual weeds in 2018/19 and 2019/20 seasons

| Seeding rates (kg)/fed. | Broad leaved weeds | | Grass weeds | | Total annual weeds | |
|-------------------------|--------------------|---------|-------------|---------|--------------------|---------|
| | 2018/19 | 2019-20 | 2018/19 | 2019-20 | 2018/19 | 2019-20 |
| 25 | 95.01 | 94.45 | 46.6 | 40.71 | 141.61 | 135.16 |
| 35 | 84.45 | 77.6 | 40.57 | 36.63 | 125.02 | 114.23 |
| F test | ** | ** | * | * | * | ** |
| LSD _{0.05} | 4.4 | 8.37 | 5.8 | 3.1 | 10.2 | 11.47 |

b. Crop growth, seed yield and yield attributes:

Data presented in Table 2 indicated that seeding rates caused considerable impact on field pea yield and its components in both seasons.

Results revealed that seeding field pea at 35 kg seeds/ fed. increased plant height, green pods yield and dry seed yield by 7.08, 13.18 and 15.73% in the first season, and 10.09, 13.07 and 11.22% in the second season, respectively, compared with 25 kg seeds/fed. The increase in plant height may be due to the competition for light in higher plant population. Meanwhile, seeding of 35 kg seeds/ fed. decreased number of branches/plant, number of pods/ plants, pods' weight/ plant, number of seeds/ pod and 100 seeds weight by 23.87, 17.59, 17.03, 13.35 and 10.03% in the first season, and by 20.06, 24.37, 16.63, 9.38 and 4.24% respectively, in the second season compared with 25 kg /fed.

The reduction in single plant characteristics may be due to the intra-specific competition for light, nutrients and space, whereas the increase in green pods and dry seed yields may be due to increasing the number of plants/fed. with increasing seeding rate from 25 to 35 kg

/fed. An earlier study conducted by Kibe and Kamithi (2007); Dahmardeh *et al.* (2010) showed that seeding rate is an important factor affecting the yield and quality of grain legumes.

2 - Effect of weed removal period:**a. Weeds dry weight (g/m²):**

Results in Table (3) showed a significant decrease in the dry weight of broad-leaved, grass and total annual weeds by all weed competition treatments in both seasons. Weed free for the whole season gave the highest reduction percentage in the dry weight of the broadleaf, grass and total annual weeds by 96.4, 92.8 and 94.0 %, and 94.4, 88.6 and 92.5%, followed by weed free up to eight weeks which reduced weeds dry weight by 87.0, 87.6 and 86.3, and 79.6, 84.7 and 81.3 %, respectively, in the first and second seasons, compared with weed competition for the whole season. Increasing the interval of weeds removal (weed free) resulted in a gradual and significant decrease in the weight of the remaining weeds until the eight weeks. These results are in accordance with those obtained by Fakkar and El-Dakkak (2015).

Table 2. The effect of seeding rates on field pea yield and its components 2018/19 and 2019/20 seasons

| Seeding rates (kg)/fed. | Plant height (cm) | Number of branches | Number of pods/ plants | Pods weight/ plant (g) | No. Seeds/ pod | Green pods yield (ton/fed.) | 100 seeds weight (g) | Dry seeds yield (ton/fed.) |
|-------------------------|-------------------|--------------------|------------------------|------------------------|----------------|-----------------------------|----------------------|----------------------------|
| 2018/19 | | | | | | | | |
| 25 | 64.95 | 3.07 | 10.8 | 47.21 | 3.97 | 1.419 | 75.16 | 0.89 |
| 35 | 69.55 | 2.34 | 8.9 | 39.17 | 3.44 | 1.606 | 67.62 | 1.03 |
| F test | * | ** | ** | ** | ** | ** | * | * |
| LSD _{0.05} | 3.83 | 0.21 | 0.99 | 3.71 | 0.06 | 0.10 | 2.68 | 0.10 |
| 2019-20 | | | | | | | | |
| 25 | 68.10 | 3.19 | 11.90 | 49.44 | 3.84 | 1.53 | 73.35 | 0.98 |
| 35 | 74.97 | 2.55 | 9.00 | 41.22 | 3.48 | 1.73 | 70.24 | 1.09 |
| F test | ** | ** | ** | ** | ** | ** | * | ** |
| LSD _{0.05} | 1.44 | 0.17 | 0.99 | 3.07 | 0.17 | 0.05 | 1.70 | 0.05 |

LSD= least significant differences

Table 3. The effect of weed removal on dry weight of grass, broad-leaved and total annual weeds in 2018/19 and 2019/20 seasons

| Weed removal | Broad leaved weeds | | Grass weeds | | Total annual weeds | |
|-------------------------|--------------------|---------|-------------|---------|--------------------|---------|
| | 2018/19 | 2019-20 | 2018/19 | 2019-20 | 2018/19 | 2019-20 |
| Weed free up to 2 WAS | 150.6 | 138.9 | 77.5 | 64.7 | 215.3 | 203.6 |
| Weed free up to 4 WAS | 120.2 | 104.2 | 46.5 | 41.2 | 161.4 | 145.4 |
| Weed free up to 6 WAS | 69.3 | 69.9 | 28.8 | 21.5 | 90.8 | 91.4 |
| Weed free up to 8 WAS | 24.1 | 35.4 | 10.9 | 12.8 | 36.9 | 48.2 |
| Whole season weed free | 6.6 | 9.7 | 6.3 | 9.5 | 16.1 | 19.2 |
| Weedy up to 2 WAS | 34.8 | 44.2 | 17.7 | 19.8 | 54.6 | 64 |
| Weedy up to 4 WAS | 66.6 | 62.9 | 36.1 | 28.6 | 95.2 | 91.5 |
| Weedy up to 6 WAS | 100 | 97.3 | 55.9 | 46.4 | 146.4 | 143.7 |
| Weedy up to 8 WAS | 140.2 | 124.4 | 69.5 | 58.8 | 199 | 183.2 |
| Whole season weed comp. | 184.9 | 173.5 | 88.1 | 83.6 | 268.5 | 257.1 |
| F test | ** | ** | ** | ** | ** | ** |
| LSD _{0.05} | 8.24 | 8.37 | 6.93 | 6.33 | 14.09 | 12.78 |

WAS= Weeks after sowing, LSD= least significant differences

b. Crop growth, seed yield and yield attributes:

Results in table (4) showed that all weed free and weed interference periods gave significant variations in plant growth characteristics, green pods and dry seed yields of field pea and its components, Plant height increased with the increase in duration of weed interference and decreased with the increase in weed-free period in the crop. Whole season weed competition gave the tallest plants (78.88 and 82.5 cm) in the first and second seasons, respectively, compared with whole season weed free which gave the shortest plants (57.0 and 60.25 cm). That effect may be due to severe competition between crop and weed for light and space in plots with increasing duration of weed interference and less in plots with increasing duration of weed-free period which allowed more space available for lateral spreading of pea plants.

During both seasons, all the yield attributes including number of branches/plant, number of pods /plant, pods weight/plant, number of seeds/pod and 100-seeds weight were influenced significantly by weed competition and weed free periods. Yield attributes increased with increasing weed-free periods and decreased with increase in weed competition period. The yield attributes were highest in weed free for the whole season and at par with weed-free for initial 8 WAS or on plots kept weed competition up to 2 weeks except number of pods/plant and pods weight per plant. This might be due to the shading effect caused by weeds which reduced the availability of light for the photosynthesis and resulted in less number of yield

attributes under weedy conditions. Akhter *et al.* (2009); Vasilakoglou and Dhima (2012) also reported decrease in yield attributes of field pea under the reduced photosynthetically active radiation conditions. Seed yield and green pods yield were highest in whole season weed free treatment and lowest in season-long weedy treatment (Table 4). Season-long weed competition caused 68.66 and 65.67% reduction in green pods yield, whereas the reductions in seed yield were 42.62 and 42.42% in the first and second seasons, respectively, compared with season-long weed free.

Yield increased significantly with increasing weed-free duration up to 8 WAS, without any significant difference with whole season weed free. This is may be due to the reduction in weed seed bank by repeated removal of weeds up to 8 WAS. Seed yield of season-long weed-free plots and plots where weed competition was allowed only for initial two weeks after sowing were not significantly different. This suggests that weeds did not start competing with crop in the initial two weeks and competition started when weeds were present for longer than two weeks.

3-Effect of interaction between seeding rates and weed competition treatments:

a. Weeds dry weight (g/m²):

Table (5) shows the effect of interaction between seeding rates and weed removal treatments on broad-leaved, grass and total annual weeds.

Table 4. The effect of weed removal on field pea yield and its components 2018/19 and 2019/20 seasons

| Weed removal | Plant height(cm) | No. of branches | No. of pods/plants | Pods weight/plant(g) | No. Seeds/pod | Green pods yield (ton/fed.) | 100 seeds weight(g) | Dry seeds yield (ton/fed.) |
|-------------------------|------------------|-----------------|--------------------|----------------------|---------------|-----------------------------|---------------------|----------------------------|
| 2018/19 | | | | | | | | |
| Weed free up to 2 WAS | 72.75 | 1.94 | 4.90 | 24.84 | 3.01 | 0.844 | 67.8 | 0.760 |
| Weed free up to 4 WAS | 65.88 | 2.58 | 7.80 | 37.46 | 3.56 | 1.375 | 71.21 | 0.920 |
| Weed free up to 6 WAS | 60.00 | 3.05 | 11.50 | 52.88 | 4.14 | 2.091 | 76.15 | 1.110 |
| Weed free up to 8 WAS | 60.24 | 3.30 | 13.50 | 60.58 | 4.34 | 2.244 | 78.15 | 1.210 |
| Whole season weed free | 57.00 | 3.41 | 15.00 | 67.58 | 4.47 | 2.269 | 78.36 | 1.220 |
| Weedy up to 2 WAS | 61.88 | 3.15 | 13.80 | 63.95 | 4.32 | 2.175 | 77.12 | 1.150 |
| Weedy up to 4 WAS | 65.50 | 2.86 | 12.40 | 42.41 | 3.94 | 1.538 | 72.62 | 0.980 |
| Weedy up to 6 WAS | 71.50 | 2.64 | 9.10 | 31.18 | 3.41 | 1.064 | 70.87 | 0.830 |
| Weedy up to 8 WAS | 78.81 | 2.43 | 6.00 | 28.88 | 3.09 | 0.815 | 66.98 | 0.760 |
| Whole season weed comp. | 78.88 | 1.70 | 4.20 | 22.18 | 2.77 | 0.711 | 64.67 | 0.700 |
| F test | ** | ** | ** | ** | ** | ** | ** | ** |
| LSD _{0.05} | 3.29 | 0.33 | 0.69 | 3.17 | 0.21 | 0.110 | 3.37 | 0.089 |
| 2019-20 | | | | | | | | |
| Weed free up to 2 WAS | 77.50 | 2.31 | 5.80 | 27.89 | 3.00 | 0.975 | 67.06 | 0.840 |
| Weed free up to 4 WAS | 73.88 | 2.84 | 8.80 | 37.76 | 3.57 | 1.376 | 71.7 | 1.000 |
| Weed free up to 6 WAS | 67.00 | 3.41 | 11.60 | 54.37 | 4.17 | 2.151 | 75.75 | 1.180 |
| Weed free up to 8 WAS | 62.25 | 3.53 | 14.30 | 61.37 | 4.40 | 2.333 | 77.85 | 1.220 |
| Whole season weed free | 60.25 | 3.86 | 15.60 | 72.87 | 4.45 | 2.415 | 78.22 | 1.320 |
| Weedy up to 2 WAS | 67.00 | 3.40 | 14.30 | 67.45 | 4.28 | 2.214 | 76.5 | 1.240 |
| Weedy up to 4 WAS | 69.75 | 2.88 | 11.40 | 44.71 | 3.76 | 1.843 | 72.05 | 1.110 |
| Weedy up to 6 WAS | 74.62 | 2.40 | 9.20 | 34.57 | 3.27 | 1.159 | 68.4 | 0.870 |
| Weedy up to 8 WAS | 80.62 | 2.15 | 6.90 | 29.17 | 2.99 | 0.990 | 65.7 | 0.810 |
| Whole season weed comp. | 82.50 | 1.95 | 5.20 | 23.12 | 2.72 | 0.829 | 64.71 | 0.760 |
| F test | ** | ** | ** | ** | ** | ** | ** | ** |
| LSD _{0.05} | 2.75 | 0.26 | 0.69 | 3.17 | 0.26 | 0.130 | 3.09 | 0.113 |

WAS= Weeks after sowing, LSD= least significant differences.

Data in table (5) revealed that the interaction between seeding rate 25 kg/fed and weed removal periods significantly affected the dry weight of grass, broad leaved and total annual weeds compared to the sowing by 35 kg/fed. seeding rate and allowing weeds grow for whole season without removal of weeds in both seasons. The least dry weight of total annual weeds was resulted from the interaction between weed removal for whole season under both seeding rates (25 and 35 kg/fed) without any significant differences between these treatments followed by weed free up to 8 WAS and both seeding rates of 25 and 35 kg/fed. in the second season; weedy up to 2 WAS and seeding rate 25 and seeding rate 35 kg/fed. in both seasons. The highest dry weight of total weeds was obtained by seeding rate 25 kg/fed. and allowing weeds to grow for whole

season, in both seasons, followed by seeding rate 35 kg/fed. without weed removal for the whole season in both seasons. These results may be due to control of weeds in early stages of field pea growth in weed free treatments and reducing the period of weed competition in early competition in weedy treatments as well as prolonging the weed free period.

b. Crop growth, seed yield and yield attributes:

Results in Table (6) indicated that, during both seasons, all the yield attributes including plant height, no. of branches/plant, number of pods/plant, pods weight/plant, number of seeds/pod and 100-seeds weight were influenced significantly by the interaction between seeding rates and weed removal treatments.

Table 5. The effect of weed removal on dry weight of grass, broad-leaved and total annual weeds in 2018/19 and 2019/20 seasons

| Seeding rates | Weed removal | Broad leaved weeds | | Grassy weeds | | Total annual weeds | |
|---------------|-------------------------|--------------------|---------|--------------|---------|--------------------|---------|
| | | 2018/19 | 2019-20 | 2018/19 | 2019-20 | 2018/19 | 2019-20 |
| 25 kg/fed. | Weed free up to 2 WAS | 156.3 | 144.7 | 83.3 | 68.6 | 239.6 | 213.3 |
| | Weed free up to 4 WAS | 130.9 | 107.2 | 53.3 | 39.4 | 184.2 | 146.5 |
| | Weed free up to 6 WAS | 72.5 | 83.5 | 36.0 | 18.7 | 108.4 | 102.2 |
| | Weed free up to 8 WAS | 21.7 | 38.4 | 10.6 | 12.6 | 32.2 | 51.0 |
| | Whole season weed free | 6.8 | 11.1 | 5.7 | 8.4 | 12.5 | 19.6 |
| | Weedy up to 2 WAS | 38.6 | 51.7 | 20.4 | 22.1 | 59.0 | 73.8 |
| | Weedy up to 4 WAS | 71.5 | 73.0 | 31.9 | 32.4 | 103.4 | 105.4 |
| | Weedy up to 6 WAS | 104.8 | 111.3 | 56.8 | 53.0 | 161.7 | 164.3 |
| | Weedy up to 8 WAS | 151.4 | 138.0 | 73.8 | 64.3 | 225.2 | 202.4 |
| | Whole season weed comp. | 195.7 | 185.6 | 94.4 | 87.6 | 290.2 | 273.2 |
| 35 Kg/fed. | Weed free up to 2 WAS | 145.0 | 133.1 | 71.7 | 60.8 | 216.6 | 193.8 |
| | Weed free up to 4 WAS | 109.4 | 101.2 | 39.7 | 43.1 | 149.2 | 144.3 |
| | Weed free up to 6 WAS | 66.2 | 56.2 | 21.7 | 24.3 | 88.0 | 80.5 |
| | Weed free up to 8 WAS | 26.5 | 32.5 | 11.3 | 13.0 | 37.8 | 45.4 |
| | Whole season weed free | 6.3 | 8.3 | 6.9 | 10.5 | 13.3 | 18.8 |
| | Weedy up to 2 WAS | 31.0 | 36.8 | 15.1 | 17.6 | 46.0 | 54.4 |
| | Weedy up to 4 WAS | 61.8 | 52.8 | 40.3 | 24.7 | 102.1 | 77.5 |
| | Weedy up to 6 WAS | 95.3 | 83.2 | 55.0 | 39.7 | 150.2 | 122.9 |
| | Weedy up to 8 WAS | 128.9 | 110.7 | 65.2 | 53.3 | 194.2 | 164.0 |
| | Whole season weed comp. | 174.1 | 161.4 | 81.8 | 79.5 | 256.0 | 240.9 |
| F test | | * | * | * | * | * | * |
| | LSD _{0.05} | 11.38 | 12.58 | 10.00 | 8.71 | 19.72 | 18.48 |

WAS= Weeks after sowing, LSD= least significant differences

The highest values for the studied growth characteristics were obtained from whole season weed free under seeding rate of 25 kg/fed. This is may be due to the less inter and intraspecific competition between field pea plants and weeds. Meanwhile, the tallest plants were obtained from whole-season weed competition under seeding rate 35 kg/fed. in both seasons. Regarding to green pods yield, it was significantly higher in seeding rate of 35 kg/fed. with whole season weed free than 25 kg/fed. with whole season weed free in both seasons. This is may be due to the role of increasing seeding rates in enhancing the ability of field pea to compete with weeds on light, nutrients and space by increasing field pea population and decreased the dry weight of weeds. Whereas the dry seed yield increased in the treated plots kept whole season weed free under seeding rate of 25 and 35 kg/fed. without any significant differences between those two treatments.

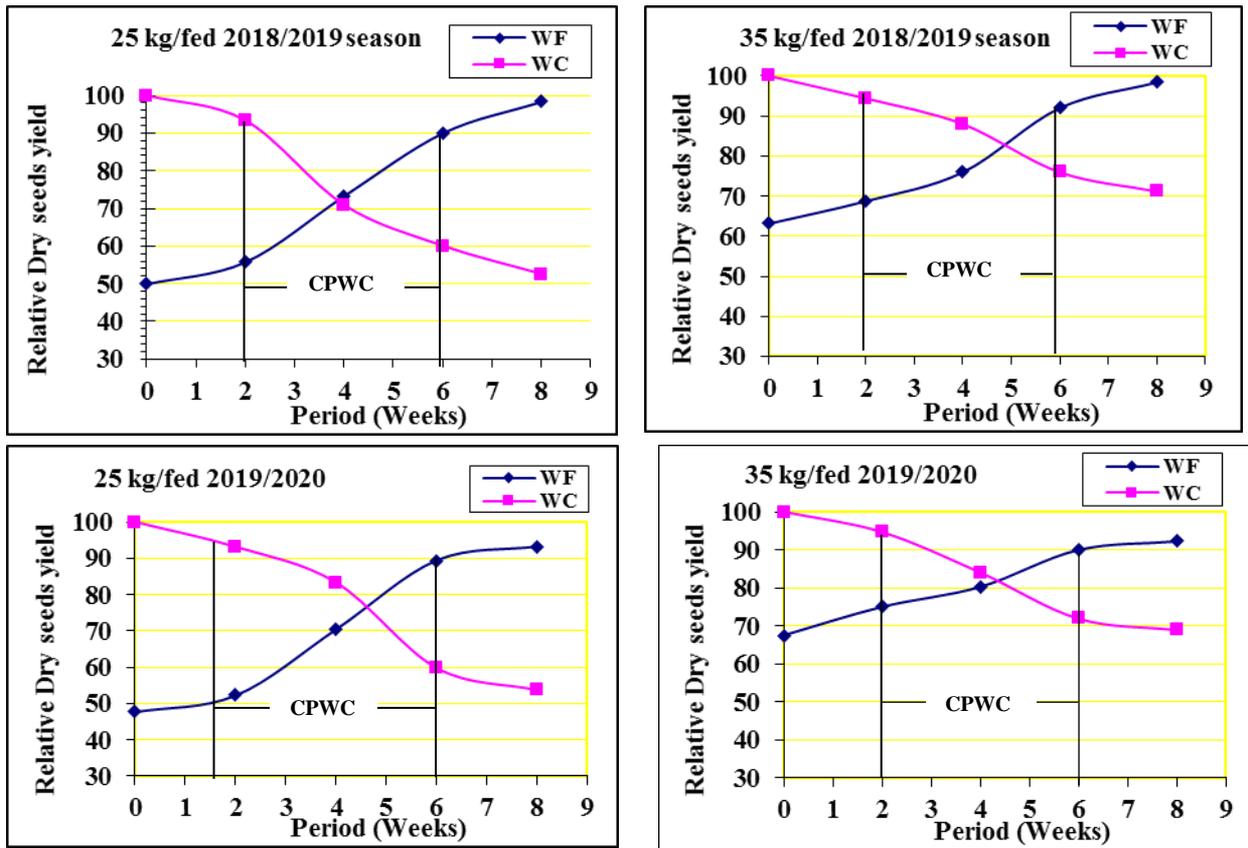
4- Estimation the critical period (CP) for weed competition in field pea fields:

Figure [1] show clearly that the critical period of weed competition with field pea started after two weeks under both seeding rates. The more the delay of weed removal the more reduction in field pea dry seed yield due to weed/ field pea competition. This may be due to the slow growth of field pea in the early growth stages. Evidently, weed free maintenance from sowing up to 6 weeks after sowing is required to maintain 90% yield of the whole season weed free. The critical period was early in seeding rate 25 kg/ fed. (4 WAS), whereas, under 35 kg/ fed. the critical period was at 5 WAS. These results are due to the increase in field pea density (plants/unit area) which increase the ability of field pea to compete with weeds than the low density (25 kg seeds/ fed.).

Table 6. The effect of interaction between seeding rates on weed removal on field pea yield and its components in 2018/19 and 2019/20 seasons

| Seeding rates | Weed removal | Plant height (cm) | No. of branches/plants | No. of pods/plants | Pods weight/plant (g) | No. Seeds/pod | Green pods yield (ton/fed.) | 100 seeds weight (g) | Dry seeds yield (ton/fed.) |
|----------------|-------------------------|-------------------|------------------------|--------------------|-----------------------|---------------|-----------------------------|----------------------|----------------------------|
| 2018/19 | | | | | | | | | |
| 25 kg/fed. | Weed free up to 2 WAS | 73.75 | 2.05 | 5.30 | 27.25 | 3.05 | 0.77 | 68.68 | 0.67 |
| | Weed free up to 4 WAS | 63.25 | 2.73 | 8.80 | 41.35 | 3.97 | 1.39 | 72.33 | 0.88 |
| | Weed free up to 6 WAS | 59.00 | 3.40 | 12.60 | 59.45 | 4.51 | 1.96 | 78.73 | 1.08 |
| | Weed free up to 8 WAS | 56.50 | 3.88 | 14.50 | 67.80 | 4.61 | 2.07 | 79.37 | 1.18 |
| | Whole season weed free | 54.75 | 3.95 | 16.30 | 72.20 | 4.76 | 2.16 | 82.46 | 1.20 |
| | Weedy up to 2 WAS | 58.25 | 3.58 | 15.30 | 69.73 | 4.65 | 2.03 | 81.98 | 1.12 |
| | Weedy up to 4 WAS | 62.75 | 3.35 | 13.20 | 43.28 | 4.30 | 1.39 | 77.77 | 0.85 |
| | Weedy up to 6 WAS | 68.25 | 3.05 | 10.40 | 33.48 | 3.67 | 0.99 | 75.43 | 0.72 |
| | Weedy up to 8 WAS | 74.25 | 2.90 | 6.90 | 33.15 | 3.27 | 0.75 | 69.25 | 0.63 |
| | Whole season weed comp. | 78.75 | 1.85 | 4.50 | 24.43 | 2.90 | 0.69 | 65.63 | 0.60 |
| 35 Kg/fed. | Weed free up to 2 WAS | 71.75 | 1.83 | 4.60 | 22.43 | 2.97 | 0.92 | 66.91 | 0.86 |
| | Weed free up to 4 WAS | 68.50 | 2.43 | 6.80 | 33.58 | 3.14 | 1.36 | 70.08 | 0.95 |
| | Weed free up to 6 WAS | 61.00 | 2.65 | 10.50 | 46.30 | 3.77 | 2.22 | 73.57 | 1.15 |
| | Weed free up to 8 WAS | 59.50 | 2.70 | 12.60 | 53.35 | 4.07 | 2.38 | 74.26 | 1.23 |
| | Whole season weed free | 63.72 | 2.95 | 13.70 | 62.95 | 4.19 | 2.42 | 76.93 | 1.25 |
| | Weedy up to 2 WAS | 65.50 | 2.73 | 12.40 | 58.18 | 4.00 | 2.32 | 72.25 | 1.18 |
| | Weedy up to 4 WAS | 68.25 | 2.38 | 11.50 | 41.55 | 3.58 | 1.69 | 67.48 | 1.10 |
| | Weedy up to 6 WAS | 74.75 | 2.23 | 7.70 | 28.88 | 3.15 | 1.14 | 66.30 | 0.95 |
| | Weedy up to 8 WAS | 83.50 | 1.95 | 5.20 | 24.60 | 2.92 | 0.88 | 64.72 | 0.89 |
| | Whole season weed comp. | 79.00 | 1.55 | 3.90 | 19.93 | 2.65 | 0.74 | 63.71 | 0.79 |
| F test | | * | * | * | ** | * | * | * | * |
| | LSD _{0.05} | 5.09 | 0.46 | 1.15 | 4.65 | 0.29 | 0.16 | 4.83 | 0.13 |
| 2019/20 | | | | | | | | | |
| 25 kg/fed. | Weed free up to 2 WAS | 72.00 | 2.35 | 6.30 | 30.05 | 3.23 | 0.90 | 67.17 | 0.69 |
| | Weed free up to 4 WAS | 70.25 | 3.13 | 10.20 | 39.65 | 3.96 | 1.21 | 70.40 | 0.93 |
| | Weed free up to 6 WAS | 62.50 | 3.78 | 13.10 | 60.15 | 4.52 | 1.94 | 75.86 | 1.18 |
| | Weed free up to 8 WAS | 60.00 | 4.15 | 16.40 | 66.10 | 4.67 | 2.21 | 79.10 | 1.23 |
| | Whole season weed free | 57.00 | 4.28 | 17.90 | 77.50 | 4.68 | 2.26 | 81.92 | 1.32 |
| | Weedy up to 2 WAS | 61.75 | 4.10 | 16.30 | 75.42 | 4.42 | 2.13 | 80.70 | 1.23 |
| | Weedy up to 4 WAS | 68.00 | 3.28 | 12.40 | 49.57 | 3.78 | 1.90 | 75.10 | 1.10 |
| | Weedy up to 6 WAS | 73.00 | 2.58 | 9.80 | 37.77 | 3.32 | 1.05 | 70.95 | 0.79 |
| | Weedy up to 8 WAS | 76.00 | 2.25 | 7.40 | 30.45 | 3.02 | 0.90 | 66.45 | 0.71 |
| | Whole season weed comp. | 80.50 | 2.05 | 5.80 | 27.72 | 2.82 | 0.77 | 65.87 | 0.63 |
| 35 Kg/fed. | Weed free up to 2 WAS | 83.00 | 2.28 | 5.40 | 25.72 | 2.76 | 1.05 | 66.95 | 0.99 |
| | Weed free up to 4 WAS | 77.50 | 2.55 | 7.40 | 35.87 | 3.17 | 1.55 | 73.00 | 1.06 |
| | Weed free up to 6 WAS | 71.50 | 2.78 | 10.20 | 48.60 | 3.83 | 2.37 | 74.52 | 1.19 |
| | Weed free up to 8 WAS | 64.50 | 3.05 | 12.30 | 56.65 | 4.13 | 2.41 | 75.65 | 1.22 |
| | Whole season weed free | 63.50 | 3.58 | 13.40 | 68.25 | 4.22 | 2.62 | 76.60 | 1.32 |
| | Weedy up to 2 WAS | 72.25 | 2.70 | 12.30 | 59.47 | 4.14 | 2.30 | 72.30 | 1.25 |
| | Weedy up to 4 WAS | 71.50 | 2.48 | 10.30 | 39.85 | 3.74 | 1.79 | 69.00 | 1.11 |
| | Weedy up to 6 WAS | 76.25 | 2.23 | 8.50 | 31.37 | 3.22 | 1.27 | 65.85 | 0.95 |
| | Weedy up to 8 WAS | 85.25 | 2.05 | 6.30 | 27.90 | 2.96 | 1.08 | 64.95 | 0.91 |
| | Whole season weed comp. | 84.50 | 1.85 | 4.50 | 18.52 | 2.63 | 0.89 | 63.55 | 0.89 |
| F test | | * | ** | ** | ** | * | ** | * | * |
| | LSD _{0.05} | 3.80 | 0.36 | 1.15 | 4.69 | 0.36 | 0.17 | 4.28 | 0.15 |

WAS= Weeks after sowing, LSD= least significant differences



WF= weed free treatments, WC= weed competition treatments

Fig .1. The critical period of weed competition for field pea yield 2018/2019 and 2019/20 seasons under 25 and 35 kg/fed. seeding rate

D- Correlation analysis:

Data in Table (7) showed that the correlation between studied weed characteristics and field pea yield components characteristics were significant in both seasons. Results indicated that green pods and dry seed yield of field pea were positively and highly significantly correlated with field pea yield and its

components namely number of pods/ plant, pods weight/plant, number of seeds/ pod and 100-seed weight, while it was negatively and significantly correlated with broad leaved, grass and total annual weeds in addition to plant height. That indicated that weed population in the experimental field exhibited severe effects due to competition with field pea crop.

CONCLUSION

Based on the results of this study, it was found that to achieve the highest field pea dry seed yield, pea's should be planted with 35 kg seeds/fed. And weeds should be controlled during the period of 2-6 weeks after sowing to minimize the impact of weed competition on pea productivity.

REFERENCES

- Akhter, N., M.M.Rahman, M. Hasanuzzaman and K. Nahar. 2009. Plant characters and seed yield of garden pea under different light intensity. *Am.-Eur. J. Agron.* 2: 152-155.
- Blackshaw, R.E. 1998. Post emergence weed control in pea (*Pisum sativum* L.) with Imazamox. *Weed Technology.* 12 (1):64 - 68.
- Dahmardeh, M., M. Ramroodi and J. Valizadeh. 2010. Effect of Plant Density and Cultivars on Growth, Yield and Yield Components of Faba Bean (*Vicia faba* L.). *Afr J. of Biot.* 9(50): 8643-8647.
- Dimitrova, T. 1998. Possibilities for chemical weed control in spring forage pea of the Pleven 4 variety. *Rasteniev"dni-Nauki.* 35 (7): 561-564.
- Fakkar, A.A.O. and A.A.A. El-Dakkak. 2015. Effect of crop sequence and weed control treatments on weeds and pea crop productivity, *Annals of Agricultural Science, Faculty of Agriculture, Ain Shams University.* 60(1) pp. 157-168.
- Gomez, K. A. and A. A. Gomez. 1984. *Statistical procedures for agricultural research.* John Wiley & Sons, Inc. New York, USA.
- Grevsen, K. 2003. Weed competitive ability of green peas (*Pisum sativum* L.) affected by seeding rate and genotype characteristics. *Bio. Agric and Hort.* 21: 247-261.
- Harker K. N., E. R. Blackshaw and G. W. Clayton. 2001. Timing weed removal in field pea (*Pisum sativum*). *Weed Tech.* 15: (277-283).
- Kibe, A. M. and D. K. Kamithi. 2007. Production Potential of Desi Chickpea Grown under Various Nitrogen and Planting Densities at Naivasha. *Agri. J.* 2(4): 520-525.
- Kumar, A., B.C.Sharma, B.Nandan and K.P. Sharma. 2009. Crop-weed competition in field pea under rainfed subtropical conditions of Kandi belt of Jammu. *Indian J. of Weed Sci.* 41(1&2): 23-26.
- Mainpal, S., K.Rakesh, K. Satish and K.Virender. 2016. Critical period for weed control in field pea. *Legume Research.* 39 (1): 86-90.
- Täckholm, V. 1974. *Students' Flora of Egypt.* Second edition, published by Cairo University, Printed by Cooperative Printing Company, Beirut, pp: 887.
- Townley-Smith, L. and A.T. Wright. 1994. Field pea cultivar and weed response to crop seed rate in western Canada. *Can. J. Plant Sci.* 74: 387-393.
- Tripathi, S.S., R.Singh, S. Singh and R.K. Singh. 2001. Study on crop-weed competition in tendril pea (*Pisum sativum* L.) under Tarai of Uttaranchal. *Indian J. of Weed Sci.* 33 (1&2): 46-48.
- Vasilakoglou, L. and D.Kico. 2012. Leafy and semi-leafless field pea competition with wild oat as affected by weed density. *Field Crop Research.* 126: 130-136.
- Wall, D.A., G.H. Freisen and T.K. Bhati. 1991. Wild mustard interference in traditional and semi-leafless field peas. *Can. J. Plant Sci.* 71: 473-480.

الملخص العربي

تحديد الفترة الحرجة لمكافحة الحشائش في محصول البسلة تحت معدلات تقاوي مختلفة

رمضان احمد موسي وخالد عباس أبوزيد ومي حسين محمد العطار

أشارت النتائج أنه بزيادة فترات المنافسة المبكرة للحشائش مع محصول البسلة أكثر من أسبوعين و/أو إنخفاض المنافسة المتأخرة عن ٦ أسابيع تؤدي إلي خفض معنوي في محصول البذور.

وفيما يخص التفاعل بين معدلات التقاوي ومعاملات منافسة الحشائش- أوضحت النتائج أن التفاعل كان معنوياً في كلا موسمي الزراعة من حيث تأثيره على جميع صفات الحشائش حيث أعطت معاملة الحفاظ على المحصول خالياً من الحشائش طوال الموسم أعلى خفض في الوزن الجاف للحشائش تحت معدلي التقاوي بدون وجود فرق معنوي بين المعدلين، بينما أعطت معاملة منافسة الحشائش طوال الموسم أعلى وزن جاف للحشائش تحت معدلي التقاوي (٢٥ و ٣٥ كجم/فدان) مع وجود فرق معنوي بين معدلي التقاوي. كما أعطي التفاعل بين معدل التقاوي ٣٥ كجم/ فدان والحفاظ علي المحصول خالياً من الحشائش لمدة ٨ أسابيع أو طوال الموسم أعلى محصول قرون وبذور/فدان.

أشارت النتائج أن جميع صفات محصول البسلة ومكوناته مثل محصول القرون الخضراء ومحصول البذور الجافة وعدد الفروع للنبات، عدد القرون/نبات، وزن القرون/نبات عدد البذور ووزن الـ ١٠٠ بذرة تأثر معنوياً بالتفاعل بين معدلات التقاوي ومعاملات منافسة الحشائش في كلا الموسمين.

أوضحت النتائج أن الفترة الحرجة لمنافسة الحشائش لمحصول البسلة تتراوح من ٢-٦ أسابيع تحت معدل تقاوي ٢٥ كجم/فدان ومن ٣-٦ أسابيع تحت معدل تقاوي ٣٥ كجم/فدان.

أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالسرو - مركز البحوث الزراعية - محافظة دمياط - مصر خلال الموسمين الشتويين ١٩/٢٠١٨ و ٢٠/٢٠١٩ لتحديد الفترة الحرجة لمنافسة الحشائش لمحصول البسلة تحت معدلين من التقاوي.

احتوت كل تجربة على عشرين معاملة عبارة عن مزيج من معدلين تقاوي (٢٥ و ٣٥ كجم تقاوي/فدان) و ١٠ معاملات منافسة: خمسة منهم عبارة فترات خلو المحصول من الحشائش لمدة ٢، ٤، ٦، ٨ أسابيع بالإضافة إلي الحفاظ على المحصول خالياً من الحشائش طوال الموسم و خمسة فترات منافسة الحشائش للمحصول لمدة ٢، ٤، ٦، ٨ أسابيع بالإضافة إلي منافسة الحشائش للمحصول طوال الموسم. واستخدم تصميم القطع المنشفة مرتين حيث وضعت معدلات التقاوي في القطع الرئيسية ووضعت معاملات المنافسة في القطع الشقية.

أوضحت النتائج أنه بزيادة معدلات التقاوي من ٢٥ إلي ٣٥ كجم/فدان أدت إلي خفض معنوي في الوزن الجاف للحشائش الحولية عريضة ورفيعة الأوراق والحشائش الحولية الكلية في كلا موسمي الزراعة. كما أدت إلي زيادة طول النبات ومحصول القرون الخضراء ومحصول البذور بنسبة ٧،٠٨، ١٣،١٨ و ١٥،٧٣% في الموسم الأول و ١٠،٠٩، ١٣،٠٧ و ١١،٢٢% في الموسم الثاني علي التوالي، مقارنة بمعدل ٢٥ كجم بذرة/ فدان، بينما أدت إلي خفض عدد الفروع للنبات، عدد القرون/نبات، وزن القرون/نبات عدد البذور ووزن الـ ١٠٠ بذرة في كلا الموسمين.