E-ISSN: 2790-6094
P-ISSN: 2957-4587

Journal Biological And Allied Health Sciences

Identifying hereditary potential of lentil (Lens culinaris L.) genotypes against tolerance to various post-emergent weedicides

Original Article

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ARTICLE INFORMATION

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Key words: Flumetsulam, Carfentrazone, Oxyflurofen, weedicides, lentil

ABSTRACT

Weed management is an essential agronomic practice to maintain yield in important crop like lentil. There is not any suitable herbicide encouraged in lentil to manage this problem because of its sensitivity. 55 different lentil genotypes were put under test to identify different weedicide tolerant genotypes. Significant differences among genotypes were observed in response to Flumetsulam, Carfentrazone and Oxyflurofen tolerance and categorized as tolerant, moderately tolerant, sensitive and highly sensitive on the basis of visual scoring. Among these a small set of 10 genotypes including tolerant and moderately tolerant were also assessed to identify the effect of herbicides on morpho-physiological parameters and yield attributes. Deleterious effect of herbicide on plant height, pods/plant, branches/plant, chlorophyll content, first pod height and yield were observed. Among all genotypes PLL-18507 and PLL-18509 demonstrated maximum tolerance and minimum yield loss against oxyflurofen treated plots.

Introduction:

Among various cool season crops lentil is among the most nutritious one. It is the cheapest source to fulfill human's protein need. Lentil is an excellent source of carbohydrates, minerals, vitamins and dietary fibers hence; it is a high energy value crop**.** It is also an important source of essential fatty acids as well. [21]. Straw of lentil is used as a source of feed of animals [22]. Since lentil is a leguminous crop so that it also improves physiological and biochemical condition of soil. Lentil is an annual highly precious leguminous food crop which evolved together with barely, wheat and many others rabi crops in Near East region almost 8000 years ago[15].

Lentil can be grown for both grain and fiber purposes. It has been noted that sometime price of straw of lentil is greater than grains. Straw of lentil is mainly use as feed of sheep due to high protein contents at international level. Branches of lentil contain protein contents ranges from 4.2 to 7.8%. Pod walls and leaflets contain protein contents ranges from 6.9 to 10.6%. Amount of crude protein in lentil is ranges from 4.5 to 5.8%. Lentil has more protein and other mineral contents as compare to cereal. Lentil is a dual purpose crop. Grains are used for human food purpose and straw is used for animals feed purpose especially for feed of sheep [8].

Area under cultivation of lentil is 17891 ha, 14623 ha and 13632 ha in 2016, 2017 and 2018 respectively [9,10,11]. Production of lentil is 7800 tonnes, 6692 tonnes and 6352 tonnes in 2016, 2017 and 2018 respectively. [9,10,11]. This data show that production of lentil is gradually decreased due to many biotic and abiotic stresses. Production is gradually decreased but demand is gradually increased due to increasing population of human as a result price of lentil is increased.

According to Economic survey of Pakistan, area under lentil cultivation is about 12.4 thousand hectares and production of lentil is 6.4 thousand tonnes. The change in production over last year is 0 percent PES (Pakistan Economic Survey 2018-19). Area under cultivation of lentil is 10.4 thousand hectares and production of lentil is 6.0 thousand tonnes. The change in production over last year is 0 percent PES (Pakistan Economic Survey 2019-20). This data also show that production of lentil is decreasing due to many biotic and abiotic diseases.

Canada ranked first in production with 2092136 tonnes production in 2018. India ranked second in production with 162000 tonnes production in 2018. Pakistan ranked 25 with production 6352 (FA0 2018). India ranked and Canada second in area wise cultivation with 2215397 ha and 1499400 ha respectively. Pakistan ranked 21 grow on 13632 hectares (FAO 2018).

Lentil has poor ability to compete with the weeds especially during early stages of growth due to low rate of plant growth and small leaf area. Weeds cause 30-70% loss in yield of lentil if not controlled at early important growth stages [4]. In previous century, weedicides were not recommended and only hoeing performed. But now a days, due to shortage of time chemicals application recommend for controlling weeds [1].

The application of farmyard manure (FYM) provides ability to lentil to compete with weeds and increase nutrients holding capacity of soil result into increase in yield of lentil. Hand weeding in lentil more significant result for controlling weeds as compare to the application of weedicide pendimethalin 0.45kg/ha. Weeds control through pendimethalin has better results than uncontrolled of weeds. Application of pendimethalin (0.45kg/ha) at pre-emergence stage has adverse effect on vegetative and reproductive yield of lentil [1].

Pakistan ranked 25 in production and 21 in area wise cultivation. This gap is due to different biotic and abiotic diseases. Weedicides tolerant lines and specific weedicides against specific weeds not available. Purpose of our experiment is to development the lentil that are resistant to weedicides and identify the weedicides that can kill the specific weed.

E-ISSN: 2790-6094
P-ISSN: 2957-4587

MATERIALS AND METHODS

Experimental site:

The experiment was laid out at the research area of Pulses Research Institute, Ayub Agricultural Research Institute, Faisalabad. (31°-26° N, 73°74° E) during *rabi* (winter) seasons of 2018-19 and 2019-20.

Lentil genotypes

In first experiment, 55 genetically diverse lentil germplasm were screened against 11 weedicides to identify tolerant lines. In all experiments sowing was completed on 1st week of November 2018-19. Second experiment was performed in 2019-20 and 12 genotypes, having different tolerance levels against weedicides were selected from last year experiment and sown in 2 blocks to determine the effect of 3 shortlisted weedicides from previous year, on various physiological, morphological and yield attributed parameters.

Plot design and weedicide application

Year 1: During 2018-19, each genotype was sown in 12 sets and these sets include one control and 11 weedicide treated plots viz (Flumetsulam, Isoproturon, Fusilade, Metribuzen, Puma Super, Percept, Sulfosulfuron, Carfentrazone, oxyfluorfen, Affinity, atlantis) in Alfa Lattice Design with two blocks. The dimensions of the plot were kept as 1 row × 1.25 m length with row to row and plant to plant spacing of 30 cm and 10 cm respectively. Post-emergence weedicides were sprayed after 50 days of sowing with a knapsack sprayer using 100 liter/acre of water following the recommended dose for chickpea.

Year 2: During experiment year of 2019-2020, a small set of 10 genotypes including some tolerant, moderately tolerant, sensitive and highly sensitive genotypes, were selected on the basis of previous year screening trial and sown in a plot with 2 rows × 4 m length using Factorial method in randomized complete block design (RCBD) with two blocks.

Scoring for weedicide tolerance

During the experiments, the injury levels due to weedicide were observed after an interval of 14 and 45 days of application. An injury level scoring scale was used as mentioned in below table.

Sr. #.	Severity level	Scoring
1.	Highly tolerant	1
2.	Tolerant	2
3.	Moderately tolerant	3
4.	Sensitive	4
5.	Highly sensitive	5

Similar scale rating method was used and proposed by Guar *et al* (2013) in chickpea. The mean value of both replications was taken into account for a genotype categorization.

Parameters taken : Five plants of each genotype were selected randomly to take plant height (cm) data at maturity using meter rod. Height of first pod was recorded from base of plant to first pod, branches and pods per plant were also counted.

Chlorophyll an essential photosynthetic pigment was also estimated using Anderson and Boardman (1964) method. The weight of 100 seeds in grams was also taken randomly from each genotype with the help of electrical weight machine. Yield per plot of each genotype were also calculated and converted into yield / ha.

Statistical analysis: CPCS1 software was used to run analysis of variance (ANOVA). The least squares means of each genotypic trait was compared with weedicide effect and the results were found significant at 5% level for all parameters under study.

Result and Discussion

First Experiment 2019-20

In first experiment, 55 different genotypes and 11 different chemicals used for the selection of suitable genotype that resist against different chemicals and selection of suitable chemical that kills weeds not plants.

Tolerance to Flumetsulam, Carfentrazone and Oxyflurofen

Apparently plant physiology is monitored to score all lentil genotypes against herbicide tolerance and a scale rating of 0-5 scale was used the results we obtained was equally reliable [12]. Screening of 55 lentil genotypes against Flumetsulam, Carfentrazone and Oxyflurofen herbicides revealed large genetic variation for tolerance to previously mentioned herbicides.

To confirm the tolerance response of these 55 lentil genotypes the experiment was repeated during 2020-21. The results obtained were used to categorize all the 55 genotypes and it was concluded that most genotypes showed susceptibility toward herbicide a few one showed moderate tolerance and no any genotype showed high tolerance.

Chronic effects of Carfentrazone and Oxyflurofen on plant growth and necrosis on lower plant leaves were observed accompanied with senescence. Complete death of susceptible plants were observed along with other abnormalities like delay in pod initiation, short plant stature, seed yield and pods per plant. Recovery in plant after 25-30 days of oxyflurofen herbicide application was noticed in many lentil genotypes.

Effect on plant population after spray

No. of plants before and after application of flumetsulam and hadaf treated plots remained almost same. While in case of carfentrazone treated plots the no. of plants after spray were reduced (Table-1).

chlorophyll content

The range of chlorophyll content varied from 40.4 to 49 nmol/cm^2 tissue for control, from 39.1 to 48 nmol/cm^2 for Flumetsulam herbicide treated plots, 24.5 to 43.8 nmol/cm^2 for carfentrazone and 40 to 47.9 nmol/cm^2 for oxyflurofen treated plots. In control PLL-18507 had the highest chlorophyll contents (49 nmol/cm^2) and minimum chlorophyll contents were observed in PLL-19507 viz. (40.4 nmol/cm^2). All the genotypes exhibited significant variations on chlorophyll content (Table-1).

E-ISSN: 2790-6094
P-ISSN: 2957-4587

Table 1: Mean values of some tolerant and moderately tolerant genotypes for NOP before spray, NOP after spray and CC.

Genotypes	NOP before spray				NOP after spray				CC nmol/cm^2			
	Control	flumetsulam	carfentrazone	Oxyflurofen	Control	flumetsulam	carfentrazone	Oxyflurofen	Control	flumetsulam	carfentrazone	Oxyflurofen
PLL-13502	17	17	17	15	17	17	17	15	44.3	42.5	39	44.5
PLL-16508	19	16	17	17	19	16	17	17	42.3	39.3	24.5	40.9
PLL-17525	17	15	18	16	17	15	17	16	44.5	42.4	40	43.8
PLL-18504	15	16	19	17	15	16	18	17	44	42	39	44
PLL-18507	18	17	18	16	18	17	17	16	49	45	42.1	47
PLL-18509	16	17	16	15	16	17	16	15	48.7	45.7	39.9	47.9
PLL-19501	19	17	16	16	19	17	16	16	45.9	43.1	37.9	43.8
PLL-19507	17	17	18	16	17	17	17	16	40.4	39.1	29.9	40
PLL-19510	19	17	18	17	19	17	17	17	48.1	48	43.8	47
PLL-19512	18	17	15	16	18	17	15	16	42.8	40	35.4	40.8

NOP = No. of Plants, **CC** = Chlorophyll Contents, **FLUMETSULAM** = Flumetsulam and **CARFENTRAZONE** = Carfentrazone

Figure. 1 No. of Plants before spray of 10 Lentils genotypes under control and weedicide stress.

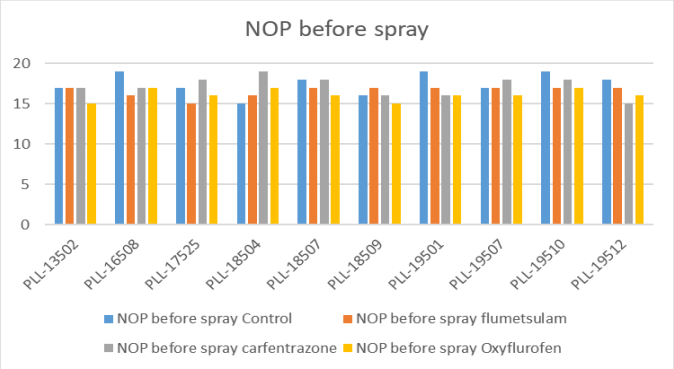


Figure. 2 No. of Plants after spray of 10 Lentils genotypes under control and weedicide stress.

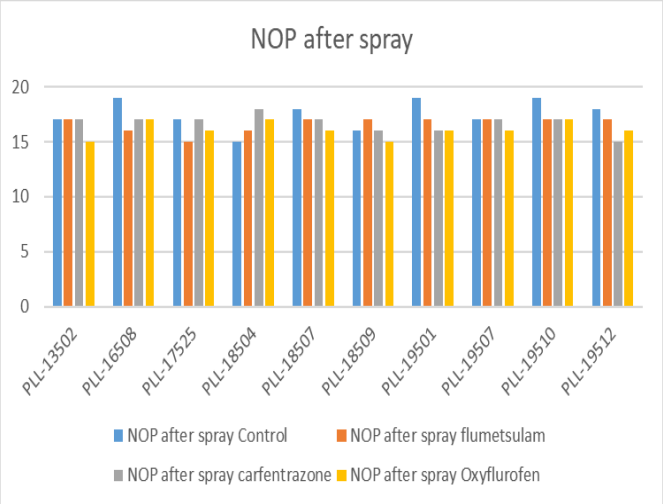
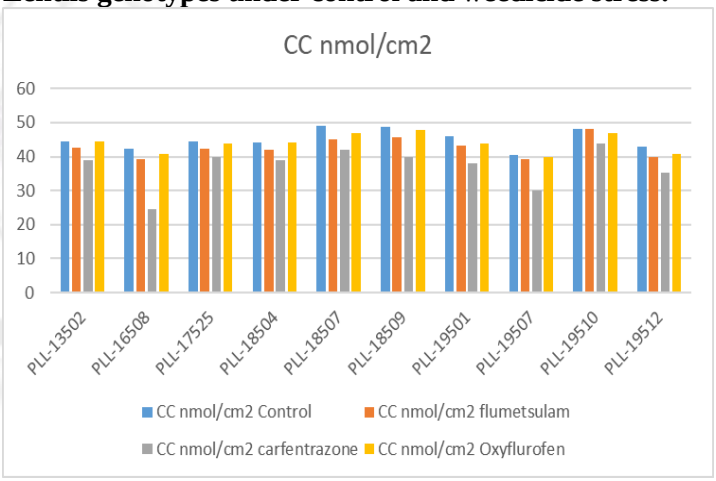


Figure. 3 Chlorophyll contents (CC nmol/cm^2) of 10 Lentils genotypes under control and weedicide stress.



Seed yield and yield attributes

Results revealed that in case of control maximum plant height was observed in PLL-19507 (45 cm) and minimum in PLL-13507 and 19510 (34 cm). In case of flumetsulam maximum and minimum plant height was indicated by PLL-19501 (46cm) and PLL-16508 (29cm) respectively. In carfentrazone treated plots maximum and minimum plant height was observed by PLL-19507 (52cm) and PLL-13502 (33cm) respectively. While in oxyflurofen treated plots maximum and minimum plant height was observed by PLL-19512 (45cm) and PLL-19510 (35cm) respectively (Table-2). and elaborated in Fig. 4, Fig. 5 and Fig. 6.

E-ISSN: 2790-6094
P-ISSN: 2957-4587

Table 2: Mean values of some tolerant and moderately tolerant genotypes for CT, PH and FPH.

Genotypes	CT				PH (cm)				FPH (cm)			
	control	flumetsulam	carfentrazone	oxyfluorofen	control	flumetsulam	carfentrazone	oxyfluorofen	control	flumetsulam	carfentrazone	oxyfluorofen
PLL-13502	8.7	8.8	9.1	8.5	34	32	33	40	25	15	11	12
PLL-16508	7.7	9.2	11	8	42	29	48	41	20	13	24	21
PLL-17525	8.2	9	10	9	41	37	35	40	15	12	20	19
PLL-18504	8.7	8.5	9	8.5	36	39	41	41	15	16	19	21
PLL-18507	9.4	9.9	10	10	42	41	43	43	14.5	10	14	21
PLL-18509	10.2	9.7	11	9.1	43	45	36	36	15	15	16	15
PLL-19501	8.6	9	8.8	8.9	40	46	48	35	16	16	22	16
PLL-19507	9	11	9.8	10	45	32	52	41	22	21	25	16
PLL-19510	8.1	8.8	11	9	34	42	40	43	15	17	12	18
PLL-19512	9.1	9.5	9	8.9	35	40	45	45	16	10	15	21

CT = Canopy Temperature, **PH** = Plant Height, **FPH** = First Pod Height, **FLUMETSULAM** = Flumetsulam and **CARFENTRAZONE** = Carfentrazone

Figure. 4 Canopy temp. of 10 Lentils genotypes under control and weedicide stress.

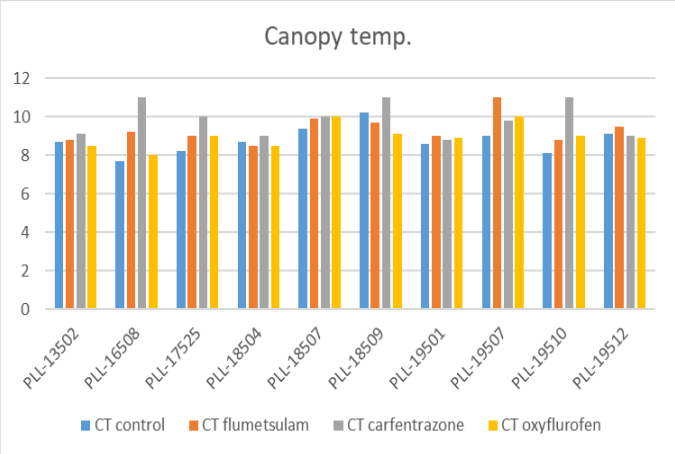


Figure. 5 Plant Height (cm) of 10 Lentils genotypes under control and weedicide stress.

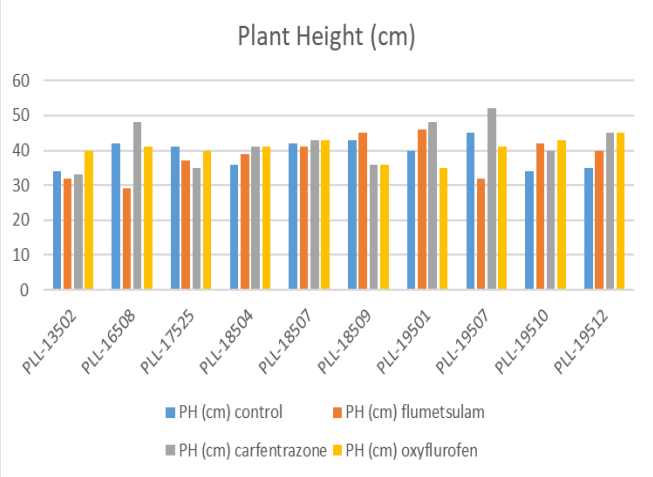
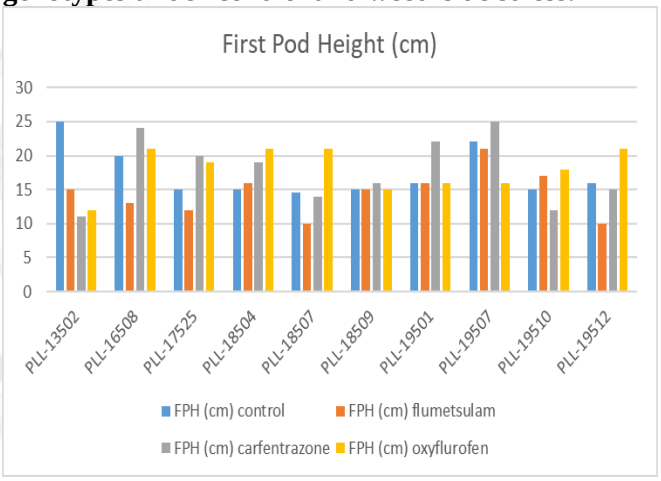


Figure. 6 First Pod Height (cm) of 10 Lentils genotypes under control and weedicide stress.



The highest first pod height in case of control was recorded by genotype PLL-13502 (25cm) and minimum by PLL-18507 (14cm). In case of flumetsulam and carfentrazone maximum pod height was recorded in PLL-19507 (21cm and 25cm) respectively (Table-2). Maximum no. of branches were observed by PLL-16508 in both control and herbicide treated plots. While maximum no. of pods per plant were observed in PLL-19501 in case of control and all herbicide treated plots. Minimum no. of pods per plant were observed in PLL-16508 in all treatments (Table-3).

E-ISSN: 2790-6094
P-ISSN: 2957-4587

Table 3: Mean values of some tolerant and moderately tolerant genotypes for NOB, NOP/plant and yield

Genotypes	NOB				NOP/Plant				Yield (kg/ha)			
	control	flumetsulam	carfentrazone	oxyflurofen	control	flumetsulam	carfentrazone	oxyflurofen	control	flumetsulam	carfentrazone	oxyflurofen
PLL-13502	14	10	11	13	402	321	333	340	747	613	660	687
PLL-16508	14	12	12	15	295	235	250	324	800	621	640	779
PLL-17525	10	8	8	10	330	292	301	335	560	480	507	560
PLL-18504	12	11	10	11	430	395	389	395	693	613	602	663
PLL-18507	8	7	8	9	390	358	360	435	1867	1087	1090	1600
PLL-18509	13	10	11	11	415	305	325	350	1634	1040	1087	1573
PLL-19501	12	12	11	10	565	567	505	501	907	900	880	903
PLL-19507	10	9	8	9	330	297	279	305	1013	960	853	993
PLL-19510	10	11	8	10	234	269	253	230	697	627	587	667
PLL-19512	9	8	11	11	301	293	341	337	740	680	647	727

NOB = No. of Branches, **NOP/Plant** = No. of Pods/ Plant, **FLUMETSULAM** = Flumetsulam and **CARFENTRAZONE** = Carfentrazone

Figure. 7 No. Of Branches of 10 Lentils genotypes under control and weedicide stress.

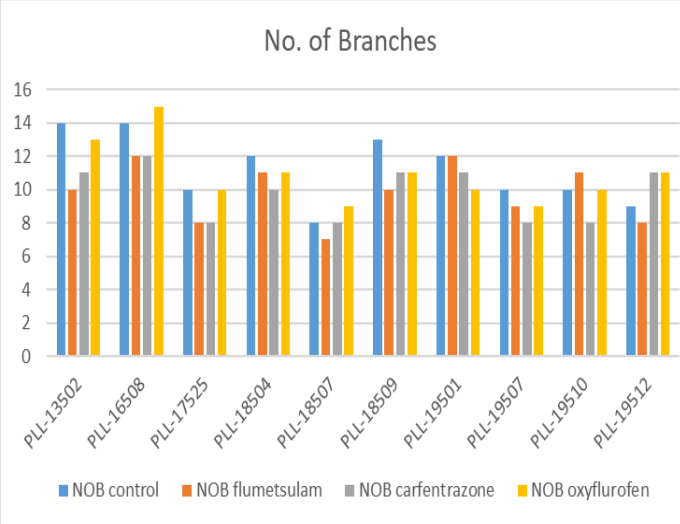


Figure. 8 No. of Pod per plant of 10 Lentils genotypes under control and weedicide stress.

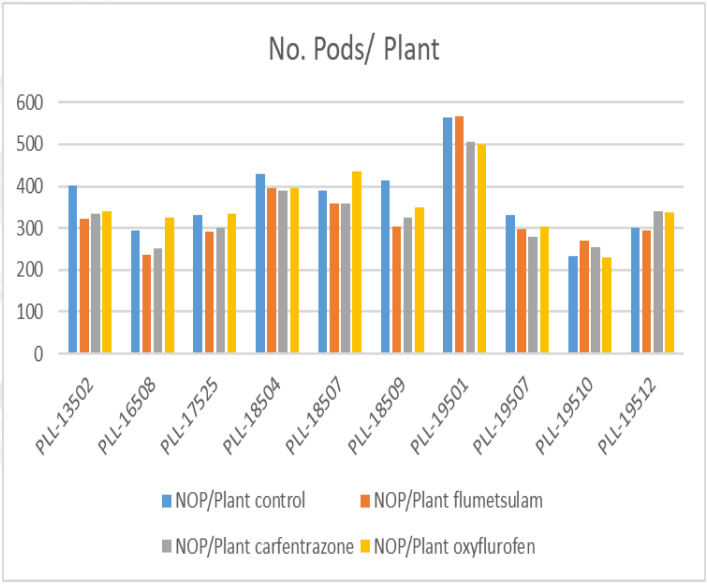
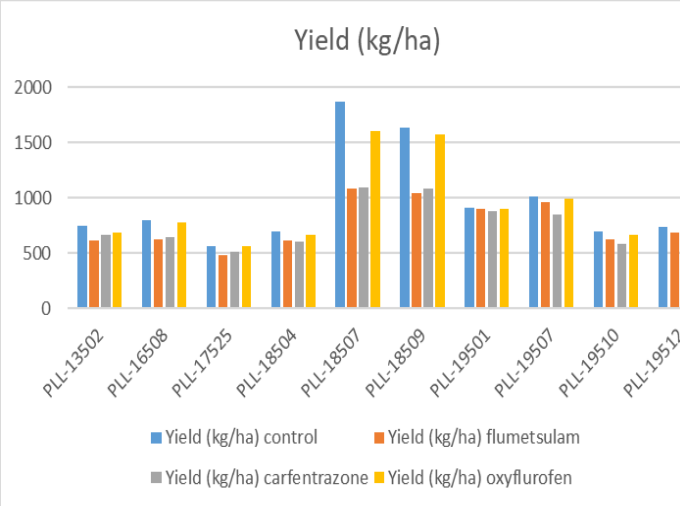


Figure. 9 Yield (kg/ha) of 10 Lentils genotypes under control and weedicide stress.



Significant reduction has been observed for yield in herbicide treated plots for all the genotypes after spray due to decrease in size and volume of seeds.

The overall maximum yield of control, flumetsulam, carfentrazone and oxyflurofen treated plots were1867,1087, 1090 and 1600 kg/ha respectively. The highest yield in case of control and treated plots were recorded by genotype PLL-18507 and PLL-18509. The minimum yield in control and treated plots were observed by PLL-17525 (Table-3).

Number of pods per plant in lentil has strong positive correlation with yield of lentil. [25]. For obtaining maximum yield of lentil, use of improved variety with disease resistance and weed control management is necessary [20].

Metribuzen is very effective weedicide for controlling broad leaves weeds with greater than 90% weed control efficiency in the Lentil [28]. Metribuzen has negative effect on vegetative and reproductive yield of lentil in wet conditions. Unweed control in the lentil has lowest number of branches/plant, number of pods/plant and grain yield as compare to weeds controlled conditions. [7]. Application of isoproutron at post-emergence and pre-emergence stage is very effective for reduction of biomass of weeds. Isoproutron is a good weedicide when apply @ 2kg/ha at post emergence stage without causing negative effect on yield of lentil. [2]. Application of weedicides at pre-emergence stage is effective for weeds control in the lentil [7,28].

Controlling of weeds by hand and application of weedicides at stage of post-emergence have equal effects on controlling of weeds in dry conditions of land in Lentil [12]. Application of pendimethalin at pre-emergence stage is less toxic as compare to application at post-emergence stage [13].

Reduction in yield of lentil in control is 56.2%, 61.6%, 34.8% and 49.8% described by [16,5,3,24], respectively. Application of imazethapyr after 25 days of sowing @ 37.5g/ha is very effective to control weeds of broad spectrum to obtain maximum yield of lentil [27]. Plants that have higher number of pods per plants have higher seed rate ultimately have higher reproductive yield.[29,13].

Cost ratio over No use of herbicide with Delayed manual weeding and weed management by Oxyfluorfen 23.5EC @ 125g a.i./ha at 2 DAS. In the *Vertisol* of Chhattisgarh. The treatment Use of Pendimethalin 30EC @1000g a.i. /ha, at 2 DAS for weed administration in chickpea showed promising impact on least weed thickness, most noteworthy weed control productivity, best return, conservative return with regards to net return and advantage: cost proportion. [17].

Major weeds of lentil were reported in Pakistan are bathu (Chenopodium album), maina (Medicago denticulata), chattri dodhak (Euphorbia helioscopia), Senji (Melilotus indica), Kandiari (Carthamus oxyacantha), lehli (Convolvulus arvensis), papra (Fumaria indica) and wild oat (Avena fatua) [27].

At 10 of the 11 locales surveyed, the selectivity of flumetsulam was not impacted by regardless of whether an adjuvant was utilized. At all destinations aside from Hart 1996, there was just nothing or slight harm noticed. At Hart 1996, harm was moderate, verging on minor. All assortments showed comparative resistance to flumetsulam. At the 7 destinations where grain yield was estimated, the grain yield of all assortments in individual preliminaries went from 82-125% of the untreated plots. The normal of across all assortments paying little mind to rate or the adjuvant utilized went from 97.5 103.3% of the untreated plots Flumetsulam applied at up to 40 g ha-1 alone or with adjuvants was specific to the seven lentil assortments in the 14 preliminaries led [20].

References

1. Aggarwal, N., & Ram, H. (2011). Effect of nutrients and weed management on productivity of lentil (Lens culinaris L.). *Journal of Crop and Weed*, *7*(2), 191-194.
2. Ali, A., Tahir, M., Malik, S. R., &Munawwar, M. H. (2014). Evaluation of pre and post-emergence weedicides for weed management in lentil (Lens culinaris Medik.). *Pakistan J.Agric. Res. Vol*, *27*(2).
3. Bhowmick, M. K., Bag, M. K., & Islam, S. (2010). Integrated weed management in lentil (Lens culinaris Medikus). *The Journal of Plant Protection Sciences*, *2*(2), 88-91.
4. Bukun, B., & Guler, B. H. (2005). Densities and importance values of weeds in lentil production. *Int. J. Bot*, *1*(1), 15-18.
6. Chandrakar, D. K., Nagre, S. K., Ransing, D. M., & Singh, A. P. (2016). Influence of different weedicides on growth, yield and economics of lentil. *Indian Journal of Weed Science*, *48*(2), 182-185.
7. Dorigo, R. (1999). The selectivity of flumetsulam to chickpeas, lentils, and vetch var. Popany. In *Proceedings of the 12th Australian Weeds Conference. Hobart, Tasmania: Tasmanian Weed Society* (pp. 306-308).
8. Elkoca, E., Kantar, F., &Zengin, H. (2004). Effects of chemical and agronomical weed control treatments on weed density, yield and yield parameters of lentil (Lens culinaris L. Cv. Erzurum-89). *Asian J Plant Sci*, *3*, 187-192.
9. Erskine, W., Rihawi, S., & Capper, B. S. (1990). Variation in lentil straw quality. *Animal Feed Science and Technology*, *28*(1-2), 61-69
10. Food and Agricultural Organization Stat (2016).
11. Food and Agricultural Organization Stat (2017).
12. Food and Agricultural Organization Stat (2018).
13. Gollojeh, k. S., ebadi, a., msohebodini, m., &sabaghnia, n.(2013). Weedicide effects on weed control and yield of lentil. , 12(1): 151-163.

14. Karadavut, U. (2009). Path analysis for yield and yield components in lentil (Lens culinaris Medik.). *Turkish Journal of Field Crops*, *14*(2), 97-104.
15. Ladizinsky, G. (1979). The origin of lentil and its wild gene pool. *Euphytica*, *28*(1), 179-187.
16. 1Ladizinsky, G., & Hymowitz, T. (1979). Seed protein electrophoresis in taxonomic and evolutionary studies. *Theoretical and Applied Genetics*, *54*(4), 145-151.
17. Lhungdim, J., Singh, Y., Kumar, P., &Chongtham, S. K. (2013). Integrated weed management of lambsquarter and nut sedge in lentil. *Indian Journal of Weed Science*, *45*(3), 192-197.
18. Parihar, B. S., Tripathi, B. P., & Sinha, P. K. (2019). Assessment of chemical weed management in chickpea (Cicer arietinum Linn.). *Journal of Pharmacognosy and Phytochemistry*, *8*(6), 2154-2155.
19. Pakistan Economic Survey (2018-19).
20. Pakistan Economic Survey (2019-20).
21. Rani, B., & Kumar, R. K. A.2019. Effect of improved variety, fungicides and weedicides on growth and yield of lentil (Lens esculenta Moench). Journal of Pharmacognosy and Phytochemistry, (5): 50-52
22. Roy, F., Boye, J. I., & Simpson, B. K. (2010). Bioactive proteins and peptides in pulse crops: Pea, chickpea and lentil. *Food research international*, *43*(2), 432-442.
23. Sarker, A., Erskine, W., & Singh, M. (2003). Regression models for lentil seed and straw yields in Near East. *Agricultural and Forest Meteorology*, *116*(1-2), 61-72.
24. Sharma S. R., S. Singh1, N. Aggarwal1, A. Kushwah1 & S. Kumar.(2017). Inherent variability among different lentil (lens culinaris medik.) Genotypes against tolerance to metribuzin weedicide. Biochem. Cell. Arch. 17 (1):49-56.
25. Singh, G., Kaur, H., & Khanna, V. (2014). Weed management in lentil with post-emergence weedicides. *Indian Journal of Weed Science*, *46*(2), 187-189.
26. Singh, S., Singh, I., Gill, R. K., Kumar, S., & Sarker, A. (2009). Genetic studies for yield and component characters in large seeded exotic lines of lentil. *Journal of Food Legumes*, *22*(4), 229-232.
27. Sultan, S., & Nasir, Z. A. (2007). Intra annual variations in weed communities of lentil fields in Chakwal, Pakistan. *Pak. J. Bot*, *38*(5), 1471-1479.
28. Teja, K. C., Duary, B., Dash, S., & Mallick, R. B. (2017). Post-emergence application of imazethapy for weed management in lentil. *SATSA Mukhapatra-Annual Technical*, *21*.
29. Yasin, J. Z., Al-Thahabi, S., Abu-Irmaileh, B. E., Saxena, M. C., & Haddad, N. I. (1995). Chemical weed-control in chickpea and lentil. *International Journal of Pest Management*, *41*(1), 60-65.
30. Younis, N., Hanif, M., Sadiq, S., Abbas, G., Asghar, M. J., &Haq, M. A. (2008). Estimates of genetic parameters and path analysis in lentil (Lens culinaris Medik). *Pak. J. Agri. Sci*, *45*(3), 44-48.
31. Balech, R., Maalouf, F., Patil, S. B., Rajendran, K., Abou Khater, L., Rubiales, D., & Kumar, S. (2023). Assessing the Stability of Herbicide-Tolerant Lentil Accessions (Lens culinaris Medik.) under Diverse Environments. *Plants*, *12*(4), 854.
32. Dhuppar P, Biyan S, Chintapalli B, Rao S (2012) Lentil Crop Production in the Context of Climate Change: An Appraisal. Indian Research Journal of Extension Education 2(Special Issue): 33-35. 2.
33. Oplinger ES, Hardman LL, Kaminski AR, Kelling KA, Doll JD (1990) Departments of Agronomy and Soil Science, College of Agricultural and Life Sciences and Cooperative Extension Service, University of Wisconsin-Madison and Department of Agronomy and Plant Genetics, University of Minnesota.

CONFLICT OF INTEREST

Authors declared no conflict of interest, whether financial or otherwise, that could influence the integrity, objectivity, or validity of their research work.

GRANT SUPPORT AND FINANCIAL DISCLOSURE

Authors declared no specific grant for this research from any funding agency in the public, commercial or non-profit sectors

DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request

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