Herbicide tolerance Faba bean, chickpea and lentils: trait disovery

Activity 1: Herbicide tolerance in faba bean at Terbol

Title	**:**	Screening of faba bean reference set for tolerance to post-emergence herbicides
Objectives	**:**	Confirm the results of tolerance level in faba bean accessions to post-emergence herbicides, Imazethapyr, Metribuzin
Activities	**:**	Continued
Observations to be taken	**:**	Crop phenology Growth and yield attributes Phytotoxic effect score (1-5)
Genotypes	**:**	132 genotypes
Expected outcomes	**:**	Sources of germplasm for tolerance to post-emergence herbicides identified
Results		132 faba bean accessions were evaluated in alpha design with 4 different herbicide treatments in four different strips with two replications: T1-Metribuzin at 350 g a.i./ha, T2: Imazethapyr at 75 g a.i./ha; T3: the combined treatments and T4: control. The plot size was one row with 2 meter length and 0.45 m width. The following data were recorded: Days to flowering, days to maturity, number of nodes up to first pod, number of pods per plant, number of branches per plant: Plant height in cm, seed weight per plant. Highly significant differences among genotypes, herbicide treatments and genotypes x herbicide treatments were observed for most of the studied traits, except for number of pods per plant (Table 1). The results showed the significant delay in flowering time and maturity in treated plots compared to the control. There was a clear reduction in overall average number of branches per plant, average seeds per plant, average of number of pods per plant and average of total seed weight. However for the selected genotypes IG11982 and IG124479 (Table 2), no difference among treatments for phenological traits (days to flowering and maturity), seed number and seed weight per plant. Those lines were the most tolerant to herbicide treatment as there was no significant differences between treatment and control.

Table 1: Mean square of analyzed traits of GCP reference set under different herbicides action: DFLR: Days to flowering, DMAT: Days to maturity, number of pods per plant, NSP NBP: number of branches per plant, PTHT: plant height in cm, SWP: seed weight per plant. *p<0.05; **p<0.01 and ***p<0.001

	DFLR	DMAT	NSP	PTHT	NPP	SWP
Rep	138.5*	19.21	6.53	2829.5***	2798.6***	380.8***
Rep x Bloc	145.8***	121.8***	295.3***	313.5***	661.4***	144.5***
Genotype (G)	496.8***	158.6***	196.2*	608.5***	315.2***	209.9***
Herbicide treatment (HT)	2711***	2654.***	571.3***	20317.3***	5449.4***	3595.9***
G X HT	45.3***	42.5**	81.6**	141.3***	169.5	48.22***

Residual	14.6	33.6	78.3	101.3	149.1	15.67
Total	98.3	63.3	135.8	245.8	211.3	82.26

Table 2: Identified lines with combined tolerance to Metribuzin and Imazethapyr.

Genotype	IG	DFLR	DMAT	PTHT	SNP
10	11982	NS	NS	NS	NS
14	12659	S	S	S	NS
27	14163	S	S	NS	NS
41	Spanish232	S	NS	S	NS
45	Spanish268	S	S	NS	NS
48	INRA286	S	NS	NS	NS
57	Spanish335	S	NS	S	NS
71	124479	NS	NS	NS	NS
72	124721	S	NS	S	NS
74	126172	S	S	S	NS
82	132194	S	NS	S	NS
83	Spanish510	S	S	S	NS
90	Spanish674	S	S	NS	NS
91	Spanish810	NS	S	S	NS
96	Spanish955	S	S	S	NS
103	INRA1482	NS	S	S	NS
104	INRA1512	S	S	S	NS
111	INRA2041	S	NS	NS	NS
115	INRA2515	S	S	S	NS
117	INRA2568	S	NS	NS	NS
118	INRA2583	S	S	NS	NS
122	103043	S	S	S	NS
124	104421	S	S	NS	NS
125	104526	NS	NS	S	NS
132	INRA2574	S	NS	NS	NS

NS: no significant differences among treatments for the selected genotypes and evaluated traits, S differences among control and the herbicide treatments. DFLR: Days to flowering, DMAT: Days to maturity, PTHT: plant height in cm, number of seeds per plant, SWP: seed weight per plant

Activity 2: Herbicide tolerance in faba bean at Terbol

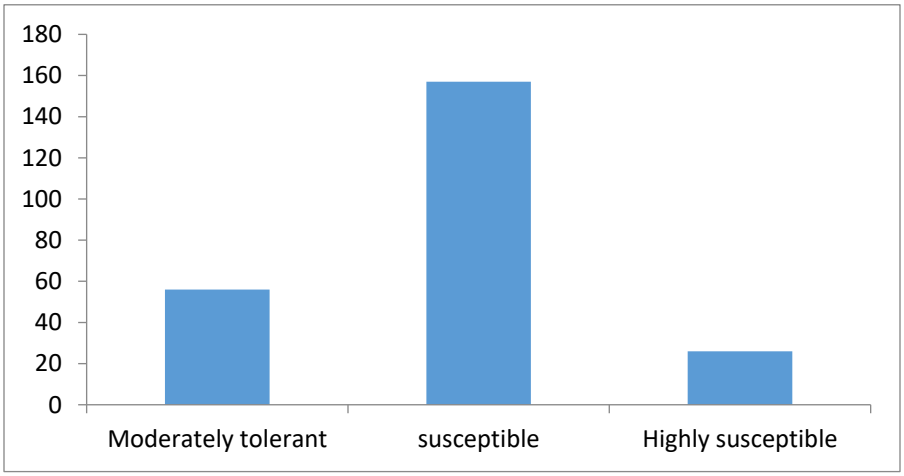
Title	**:**	Screening of faba bean reference set for tolerance to glyphosate tolerance
Objectives	**:**	Confirm the results of tolerance level in faba bean selected mutant lines for glyphosate tolerance
Activities	**:**	Continued
Expected Outcomes	**:**	Sources for tolerance to glyphosate resistance identified
Observations to be taken	**:**	Crop phenology Growth and yield attributes Phytotoxic effect score (1-5) Yield components for treated and none treated plots
Genotypes	**:**	240 M5 single plants selected for their tolerance to glyphosate
Results		240 faba bean single plants derived from single plant selection of screening field to glyphosate tolerance of M5 BPL 710 mutagenized population were screened for glyphosate @ 1200 g ai/ha in open field in Terbol Research station. The genotypes were scored for phytotoxic effect of glyphosate on 1 to 5 scale. The mutant lines were classified as follows: • 56 mutant lines were scored 2 and considered tolerant 157 were scored 3 and 4 and were considered moderately susceptible • 27 lines were highly susceptible to glyphosate. (Fig1). Significant differences among the tested entries and the treatments for seed number per plants were observed (Table 1). Comparison of means using student t-test revealed that among the tolerant lines, only 29 selected lines did not show significant differences between treated plot and the control for the number of seeds per plant (Table 2).  Fig. 1: Distribution of the mutant lines to different tolerance level to glyphosate.

Table 1: Analysis of variance for number of seeds per plot

Change	m.s.	F pr.
Rep	0.04	0.979
+Rep.BLK	149.97	<.001
Entry	72.42	0.006
Treat	40268.83	<.001
Entry xTreat	35.64	0.996
Residual	52.34	
Total	118.31	

Table 2: Identified lines with tolerance by using student t-test.

Sel.name	Genotype	Filial	Tc
8-1	Mu-346	M5	1.876463
17-1	Mu-247	M5	1.953186
25-1	Mu-186	M5	1.643693
52-1	Mu-137	M5	1.829649
70-1	Mu-56	M5	0.301691
138-7	Mu-77	M5	0.972692
98-3	Mu-3	M5	1.560468
146-1	Mu-72	M5	1.364109
150-2	Mu-160	M5	1.263979
159-1	Mu-488	M5	1.864759
161-1	Mu-313	M5	0
163-1	Mu-151	M5	1.73342
195-1	Mu-168	M5	1.442133
195-2	Mu-168	M5	1.817945
196-1	Mu-204	M5	1.708713
240-1	Mu-64	M5	-0.06762
348-1	Mu-437	M5	1.646294
355-5	Mu-238	M5	1.882965
360-1	Mu-303	M5	1.756827
360-2	Mu-303	M5	1.6658
369-1	Mu-516	M5	1.387516
27-1	Mu-409	M5	1.491547
84-1	Mu-53	M5	1.339402
298-1	Mu-175	M5	0.763329
356-1	**Mu-418**	**M5**	**1.018205**
65-1	Mu-476	M5	1.815345
251-1	Mu-235	M5	0.997399
287-1	Mu-178	M5	0.780234
302-1	Mu-503	M5	0.552666

Activity 3: Herbicide tolerance in faba bean at Terbol

Title	**:**	Screening of faba bean reference set for tolerance to Metribuzin and Imazethapyr tolerance
Objectives	**:**	Evaluation of the selected lines for mechanical harvesting to herbicide tolerance
Activities	**:**	New
Observations to be taken	**:**	Crop phenology Growth and yield attributes Phytotoxic effect score (1-5) Yield components for treated and none treated plots
Genotypes	**:**	255 genotypes selected for metribuzin tolerance and mechanical harvestable traits
Expected Outcomes	**:**	Lines with mechanical harvesting and metribuzin tolerance identified.
Results		255 breeding lines previously selected for metribuzin tolerance evaluated in strip-plot design with two treatments and two replications. Significant differences among genotypes and treatments observed for days to flowering (DFLR), number of pods per plant (NPP), number of seeds per plant (NSP) and plant height (PTHT). Among the tested lines only 25 were selected as tolerant to Metribuzin, Imazethapyr.

Table 1: Analysis of variance for evaluated traits

Change	DFLR	DMAT	NNFP	NPP	NSP	PTHT
Treatment (T)	2.11	10791.6***	11.7***	271.18***	3750.05***	5553.06***
T X Block	144.9***	154.84*	1.09***	102.48***	256.9***	198.32***
Genotypes	47.2***	82..1	0.15	21.05***	53.39***	83.38***
Residual	12.48	76.53	0.11	14.53	36.98	54.88

Days to flowering (DFLR), Day to maturity (DMAT), number of nodes till first pods, number of pods per plant (NPP), number of seeds per plant (NSP) and plant height (PTHT)

Table 2: Selected lines with combined tolerance to Imazethapyr and Metribuzin

Selection name	cross/firstsel	DFLR	NPP	NSP	PTHT
1028-2/2014	Selection from ELIzar-2013	94.5	10.165	20.16	60.33
1028-3/2014	Selection from ELIzar-2013	96	13.835	31.66	63.49
1030-1/2014	F6 (Fam 2-1-1 X F7/8975/05)-THTRTR-85-2	94.5	10.5	21	62.49
1041-2/2014	WRB 1-4 X F7/8983/05/S 2008, 092	99	11.335	19.83	73.33
1056-2/2014	F7/8986/05 X sel 2004 latt 214/S 2008, 053	96	12.665	23.83	77.33
1424-1/2014	F7/8986/05 X sel2004latt25/S 2008, 011	96	41.33	14.66	61.5
2032-1/2014	Ac1210/4920;R XAc0059/8055;S	104.5	13	25	65.83
2042-1/2014	WRB 1-4 X F7/8983/05/S 2008, 092	99	10.66	21.84	63.99
2078-1/2014	F7/8992/05 X sel 2004 latt 78-2/S 2008, 066	96	10.16	21	66.17

2080-2/2014	F7/8992/05 X sel 2004 latt 78-2/S 2008, 066	99	11.16	17.5	66
2105-1/2014	DT/B7/7986/0405-S98013 (DC)	101	11.5	17.83	75.33
2150-1/2014	F6 (F7/8975/05 X sel2004latt.47-1)-THTRTR-23-7	99	11.33	25	61.16
2270-1/2014	Selection from ILB1814-2013	97.5	16.33	34.33	57.83
2291-1/2014	F7/8983/05 X sel 2004 lat 393-1/S 2008, 076	97.5	10.16	21	64.16
2294-2/2014	F7/8983/05 X sel 2004 lat 393-1/S 2008, 076	102	11	22.67	59.99
2297-2/2014	F7/8983/05 X sel 2004 lat 393-1/S 2008, 076	96	12.83	21.66	65.17
2340-3/2014	F7/8990/05 X sel2004latt.8/S 2008, 005	97.5	10.66	22.33	64.83
2352-1/2014	Aguadulce X sel2004 latt.69.3/S 2008, 028	99	10.16	22.66	56.5
2389-3/2014	Ac0059/8055;S XAc1281/7058;R	99	10.5	19.83	64.66
2400-1/2014	**HBP/SOD/2000**	96	10.66	19.83	67.49
2603-2/2014	F7/8986/05 X sel2004 latt.69.3/S 2008, 027	108	21.66	40.5	65.66
2622-1/2014	F7/8983/05 X sel2004latt25/S 2008, 016	96	10.33	15.83	74.5
2637-1/2014	**HBP/SOD/2000**	97.5	11.5	22.83	72.83
2725-1/2014	F7/7381/05-HBP/S0D/2000	98	13.65	31.33	80.99
Khalil		99	10.67	21.33	71.83

Activity 4: Herbicide tolerance in faba bean at Marchouch

Title	**:**	Screening of faba bean reference set for tolerance to post-emergence herbicides
Objectives	**:**	Confirm the results of tolerance level in selected faba bean accessions to post-emergence herbicides, Imazethapyr and Metribuzin
Activities	**:**	Continued
Expected outcomes	**:**	Sources of germplasm for tolerance to post-emergence herbicides identified
Observations to be taken	**:**	Crop phenology Growth and yield attributes Phytotoxic effect score (1-5)
Genotypes	**:**	45 selected lines based on last year results
Results		Screening of 45 faba bean selected tolerant to moderate tolerance genotypes for two post-emergence herbicides, Metribuzin (photo-synthesis inhibitor) and Imazethapyr (amino acid synthesis inhibitor) was carried out in Morocco during 2015-16 to validate the results of herbicide tolerance level. Metribuzin @ 175 g a.i./ha and Imazethapyr @ 75 g a.i./ha sprayed at 7-8 node stage and phytotoxic effect was scored at 2- and 5-week after spray on a 1-5 scale. The data on plant height, days to 50% flowering, days to maturity and yield were recorded in both herbicide treated and control treatment. The

herbicide tolerance score varied from 2 to 5 for Metribuzin and 3 to 5 for Imazethapyr. Table 1 and Fig 1 showed very few expressed tolerance level of 2 to Metribuzin herbicides. In general, the sensitivity for Imazethapyr was higher as compared to that for Metribuzin. Of the 45 tested genotypes, only 2 genotypes were found tolerant to Metribuzin and 15 genotypes moderately tolerant to Imazethapyr and 21 genotypes to Metribuzin.

Table 1: Grouping of herbicides based on herbicide tolerance level

HRS	Category	Number of genotypes	
		Imazethapyr	Metribuzin
1	Highly tolerant	0	0
2	Tolerant	0	2
3	Mod. Tolerant	15	21
4	Susceptible	23	15
5	Highly susceptible	7	7

*HRS: Herbicide tolerance score

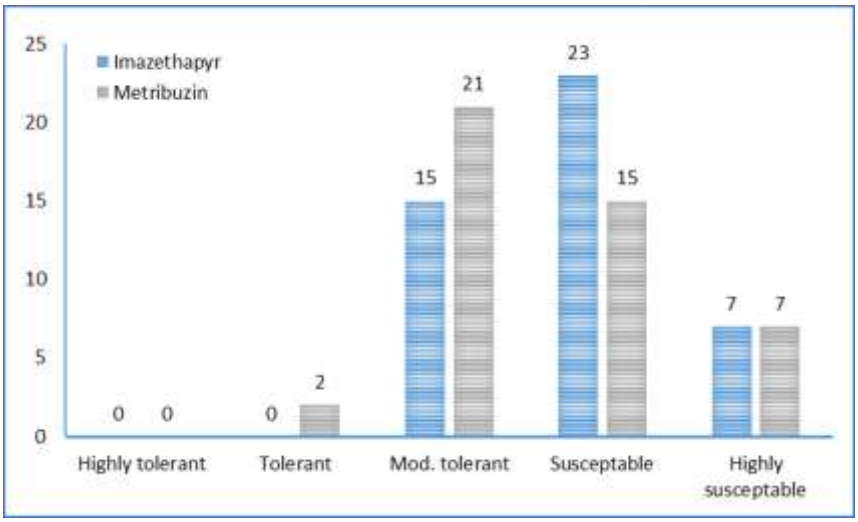


Fig. 1: Grouping of herbicides based on herbicide tolerance level

Activity 5: Herbicide tolerance in lentil

Title	**:**	Validation of results of herbicide tolerance level in the selected lentil germplasm
Objectives	**:**	Confirm the results of herbicide tolerance level in lentil germplasm
Activities	**:**	Continued

<table>
<tr><td>Expected outcomes</td><td>:</td><td>Sources of germplasm for tolerance to post-emergence herbicides identified</td></tr>
<tr><td>Observations to be taken</td><td>:</td><td>Crop phenology
Growth and yield attributes
Phytotoxic effect score (1-5)</td></tr>
<tr><td>Genotypes</td><td>:</td><td>
<table>
<tr><td>ILL7213</td><td>ILL7661</td><td>ILL2684</td><td>2007S 96811-18</td></tr>
<tr><td>ILL9997</td><td>ILL10812</td><td>Chakkouf</td><td>ILL4401</td></tr>
<tr><td>ILL89517</td><td>010S 96130-1</td><td>GCP 34</td><td>ILL5588</td></tr>
<tr><td>ILL7915</td><td>ILL5562</td><td>ILL2445</td><td>ILL10690</td></tr>
<tr><td>ILL6024</td><td>Bakaria</td><td>GCP99</td><td>ILL0170</td></tr>
<tr><td>ILL9977</td><td>ILL10826</td><td>ILL4400</td><td></td></tr>
<tr><td>ILL7984</td><td>ILL5244</td><td>ILL4605</td><td></td></tr>
<tr><td>ILL7668</td><td>ILL1455</td><td>ILL7679</td><td></td></tr>
<tr><td>ILL0590</td><td>ILL0195</td><td>L24</td><td></td></tr>
<tr><td>ILL10810</td><td>ILL10948</td><td>ILL5883</td><td></td></tr>
<tr><td>ILL7701</td><td>06S 53110-02</td><td>ILL0857</td><td></td></tr>
<tr><td>2007S 96801-8</td><td>ILL6434</td><td>ILX87075</td><td></td></tr>
<tr><td>GCP10</td><td>2009S 96568-1</td><td>ILL0462</td><td></td></tr>
<tr><td>ILL10833</td><td>ILL8009</td><td>ILL10825</td><td></td></tr>
<tr><td>ILL7532</td><td>ILL7210</td><td>010S 96155-2</td><td></td></tr>
</table>
</td></tr>
<tr><td>Results</td><td>:</td><td>Screening of 50 lentil genotypes for tolerance to two post-emergence herbicides, Metribuzin and Imazethapyr, demonstrated a potential genetic variation for tolerance to these herbicides. Metribuzin @ 175 g a.i./ha and Imazethapyr @ 75 g a.i./ha was sprayed at 7-8 node stage and phytotoxic effect was scored at 2- and 5-week after spray on a 1-5 scale. On a scale from 1 to 5 (where as 1 being highly tolerant and 5 being highly sensitive), the level of herbicide tolerance was ranged from 2 to 5 for Metribuzin and 3 to 5 for Imazethapyr (Table 1). It was identified that most of the genotypes have shown increased sensitivity to both of these herbicides this year due to chemical stress coupled with the soil moisture stress at early growth stage and only 5 genotypes have demonstrated tolerant to Metribuzin but no tolerant genotypes for Imazethapyr identified. One genotype demonstrated moderate tolerance to Imazethapyr and 19 genotypes to Metribuzin (Figure 1). In general, the sensitivity for Imazethapyr was higher as compared to that for Metribuzin. Herbicides affected the growth and development of the susceptible lines.
Genotypes demonstrating high sensitivity to Metribuzin showed yellowing of lower leaves followed by premature leaf senescence and complete plant death. On the other hand, the susceptible genotypes to Imazethapyr affected the growing shoot tips and branches and complete plant death was observed in highly sensitive genotypes. An overall delay in flowering, deformation of flowers, poor pod setting and reduction in pod and seed size was also observed in these experiments.</td></tr>
</table>

Table 1: Grouping of lentil genotypes on basis of herbicide tolerance score

HTS*	Category	Number of genotypes	
		Imazethapyr	Metribuzin
1	Highly tolerant	0	0
2	Tolerant	0	5
3	Moderately tolerant	1	19
4	Susceptible	15	19
5	Highly susceptible	34	7

*HTS: Herbicide tolerance score

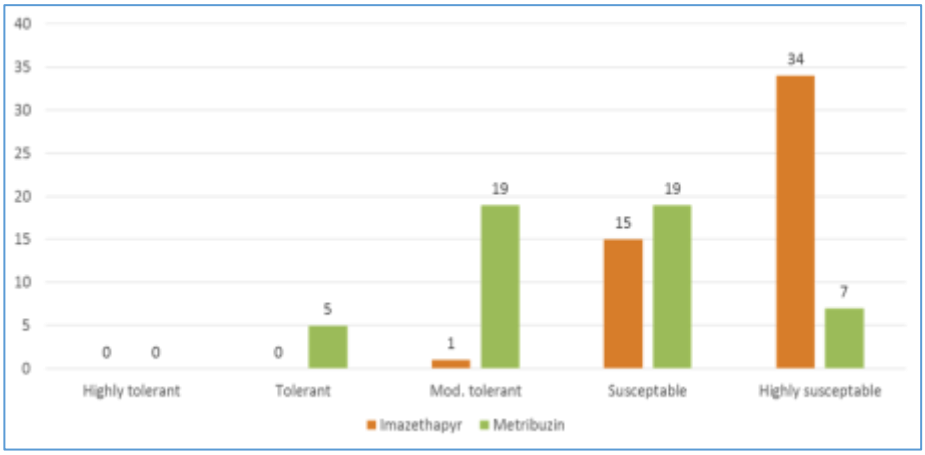


Figure 2: Grouping of lentil genotypes on basis of herbicide tolerance score

Activity 6: Herbicide tolerance in chickpea

Title	**:**	Screening of chickpea germplasm set for post-emergence herbicide tolerance
Objectives	**:**	Identify the sources of tolerance to post-emergence herbicides, Imazethapyr and Metribuzin
Activities	**:**	New
Expected outcomes	**:**	Chickpea germplasm sources for tolerance to various group of post-emergence herbicides identified
Observations to be taken	**:**	Crop phenology Growth and yield attributes Phytotoxic effect score (1-5)
Genotypes	**:**	FLIP07-218C, FLIP09-306C, FLIP09-201C, FLIP09-109C, FLIP09-76C FLIP09-36C, FLIP09-310C, FLIP09-207C, FLIP09-112C, FLIP09-84C FLIP09-37C, FLIP09-312C, FLIP09-208C, FLIP09-115C, FLIP09-98C FLIP09-58C, FLIP09-313C, FLIP09-209C, FLIP09-123C, FLIP09-128C

		FLIP09-59C	FLIP09-316C	FLIP09-218C	FLIP09-130C	FLIP09-134C
		FLIP09-62C	FLIP09-317C	FLIP09-219C	FLIP09-147C	FLIP09-138C
		FLIP09-93C	FLIP07-209C	FLIP09-263C	FLIP09-161C	FLIP09-146C
		FLIP09-94C	FLIP07-220C	FLIP09-280C	FLIP09-162C	FLIP09-154C
		FLIP09-95C	FLIP07-227C	FLIP09-282C	FLIP09-163C	FLIP09-155C
		Arifi	FLIP08-82C	FLIP09-283C	FLIP09-165C	FLIP09-156C
		FLIP09-105C	FLIP08-83C	FLIP09-286C	FLIP09-167C	Elixir
		FLIP09-110C	FLIP08-84C	FLIP09-298C	FLIP09-175C	FLIP07-47C
		FLIP09-135C	FLIP09-7C	FLIP07-187C	FLIP09-177C	FLIP05-170C
		FLIP09-148C	FLIP09-99C	FLIP07-201C	FLIP09-181C	FLIP07-34C
		FLIP09-229C	FLIP09-121C	FLIP07-217C	FLIP09-182C	FLIP08-197C
		FLIP09-240C	FLIP09-133C	FLIP07-225C	FLIP09-188C	FLIP07-295C
		FLIP09-285C	Zahour	FLIP09-2C	FLIP09-217C	FLIP07-340C
		FLIP09-289C	FLIP09-149C	Rizki	FLIP09-260C	FLIP07-307C
		FLIP09-290C	FLIP09-158C	FLIP09-4C	FLIP07-184C	FLIP09-304C
		FLIP09-291C	FLIP09-159C	FLIP09-5C	FLIP07-197C	FLIP09-314C
		FLIP09-292C	FLIP09-160C	FLIP09-8C	FLIP07-199C	FLIP07-330C
		FLIP09-293C	FLIP09-186C	FLIP09-40C	FLIP07-211C	FLIP07-304C
		FLIP09-294C	Farihane	FLIP09-47C	FLIP07-221C	FLIP88-85C
		FLIP09-297C	FLIP09-191C	FLIP09-65C	FLIP07-223C	FLIP08-49C
		FLIP09-303C	FLIP09-193C	FLIP09-107C	FLIP09-49C	FLIP06-130C
						Moubarak
Results	**:**	A set of 126 chickpea genotypes, including germplasm accessions and advanced breeding lines, were screened for post-emergence herbicides at ICARDA experimental station, Marchouch, Morocco. Herbicides were sprayed on 55-60 days old seedlings during evening timing when the air movement was gentle. Imazethapyr @ 75 g a.i./ha and Metribuzin @ 175 g a.i./ha was sprayed at the rate of 375 litre spray volume per hectare using backpack sprayer. Herbicide damage score was recorded based on visual observations at 2- and 5- week after spray on a 1–5 scale in two replications; where 1 = highly tolerant (no plant damage), 2 = tolerant (good health with minor leaf burning and chlorosis of leaves), 3 = moderately tolerant (moderately healthy with medium level of burning and chlorosis of leaves), 4 = sensitive (poor health with severe burning and chlorosis of leaves), and 5 = highly sensitive (complete plant death). The data related to phenology and seed yield traits were recorded in both sprayed and control treatment. Results indicated that significant genotypic differences for herbicide tolerance observed among set of tested chickpea germplasm accessions. Genotypes were scored and grouped into different categories based on the level of tolerance recorded at five weeks after spray (Table 1 and Figure 1). These herbicides developed different type of toxic symptoms on leaves. Metribuzin, developed chlorosis and necrosis on older leaves followed by premature senescence and complete death of highly susceptible genotypes. On the other hand, Imazethapyr caused yellowing of leaves and killed the growing tips of the branches and finally complete death of the plants was					

observed. Overall, growth, and delayed flowering and poor pod set was observed in all the tested genotypes. These results identified none of the genotypes were found as highly tolerant to both of these herbicides. Of the 126 tested accessions, only 17 (13.5%) lines have shown moderate tolerance to Imazethapyr and seven (0.06%) lines moderately tolerant to Metribuzin.

Table 1. Different groups of chickpea accessions on basis of herbicide tolerance level measured at five weeks after spray.

HTS*	Category	Number of accessions	
		Imazethapyr	Metribuzin
1	Highly tolerant	0	0
2	Tolerant	0	0
3	Moderately tolerant	17	7
4	Susceptible	58	52
5	Highly susceptible	51	67

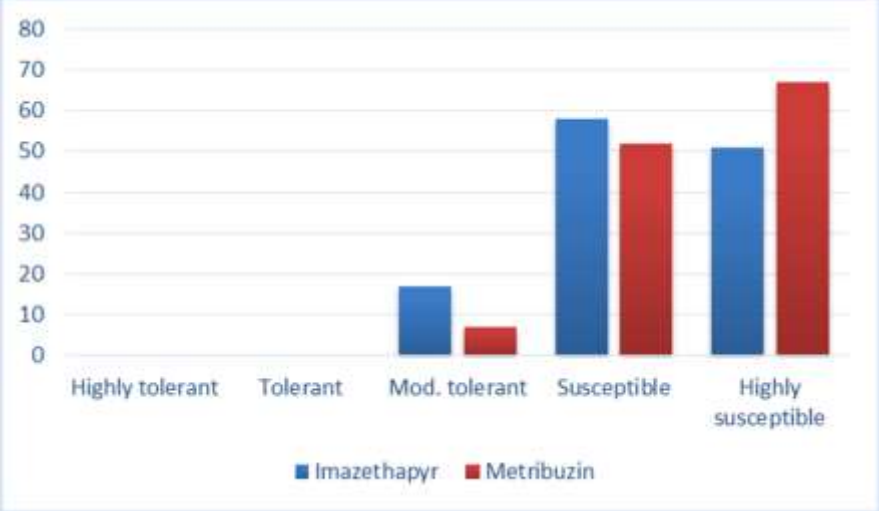
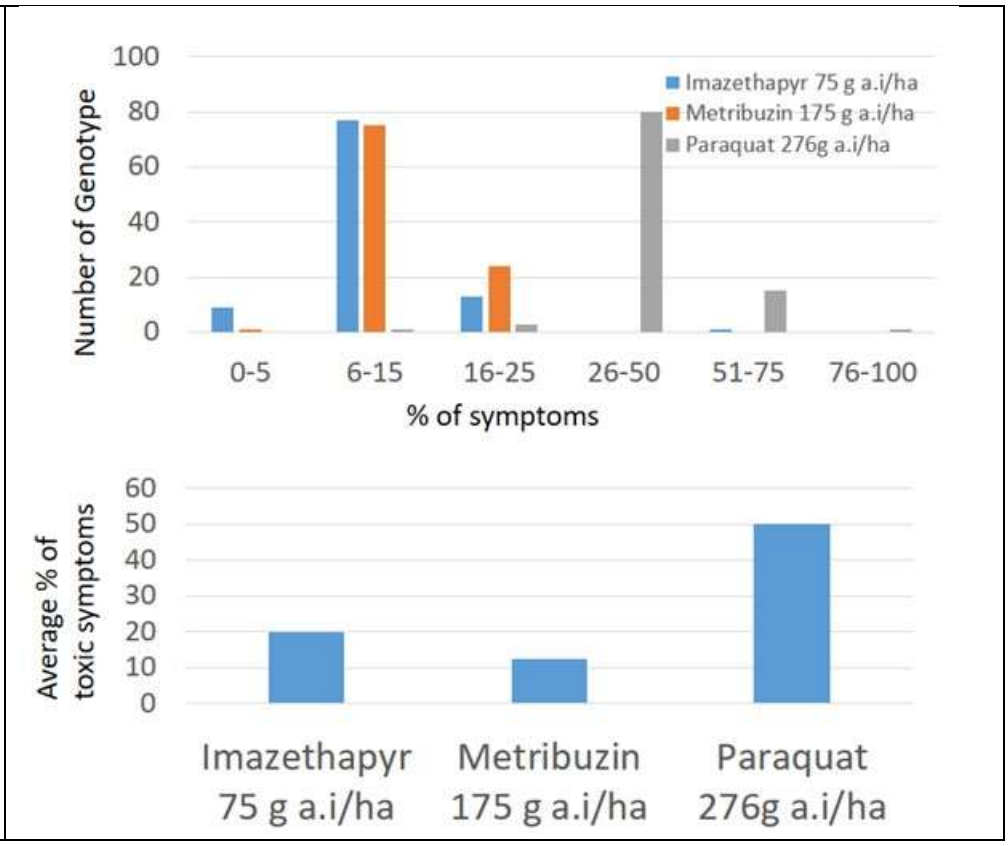


Figure 1: Grouping of chickpea accessions on basis of herbicide tolerance level

Title	**:**	Screening of chickpea germplasm set for post-emergence herbicide tolerance in Terbol (Lebanon)
Objectives	**:**	Identify the sources of tolerance to post-emergence herbicides, Imazethapyr and Metribuzin
Activities	**:**	New
Expected outcomes	**:**	Chickpea germplasm sources for tolerance to various group of post-emergence herbicides identified
Observations to be taken	**:**	Crop phenology Growth and yield attributes Phytotoxic effect score (1-5)

Genotypes	**:**	CP1060546, FLIP05-27C, FLIP07-320C, FLIP08-49C, FLIP98-121C Elixir, FLIP05-72C, FLIP07-322C, FLIP08-69C, ICC12004 FLIP 81-293C, FLIP06-87C, FLIP07-325C, FLIP08-99C, ICCV96030 FLIP 81-71C, FLIP07-114C, FLIP07-32C, FLIP82-150C, ILC 182 FLIP 84-182C, FLIP07-119C, FLIP07-330C, FLIP83-7C, ILC 195 FLIP 84-79C, FLIP07-142C, FLIP07-344C, FLIP84-188C, ILC 2555 FLIP 84-92C, FLIP07-143C, FLIP07-34C, FLIP84-48C, ILC 464 FLIP 85-17C, FLIP07-20C, FLIP07-43C, FLIP87-59C, ILC 484 FLIP 85-1C, FLIP07-214C, FLIP07-75, FLIP88-85C, ILC 72 FLIP 86-5C, FLIP07-217C, FLIP08-117C, FLIP90-96C, ILC1302 FLIP 86-6, FLIP07-21C, FLIP08-160C, FLIP93-146C, ILC263 FLIP 87-45C, FLIP07-245C, FLIP08-170C, FLIP93-93C, ILC3279 FLIP 87-8C, FLIP07-257C, FLIP08-189C, FLIP97-137C, ILC3397 FLIP 91-77C, FLIP07-27C, FLIP08-197C, FLIP97-263C, ILC482 FLIP 93-58C, FLIP07-284C, FLIP08-200C, FLIP97-266C, ILC533 FLIP02-7C, FLIP07-295C, FLIP08-22C, FLIP97-503C, ILC605 FLIP03-124C, FLIP07-300C, FLIP08-254C, FLIP97-530C, WR-315 FLIP03-23C, FLIP07-304C, FLIP08-256C, FLIP97-677C, X10TH208 FLIP04-5, FLIP07-308C, FLIP08-257C, FLIP97-7, X10TH41 FLIP05-170C, FLIP07-31C, FLIP08-34C, FLIP97-706C, X10TH8
Results	**:**	Three different herbicides (Imazethapyr 75 g a.i/ha; Metribuzin 175 g a.i/ha; Paraquat 276 g a.i/ha) were used in this study to screen 100 chickpea germplasm accessions for herbicide tolerance. Genotypes were scored based on the percentage of toxic symptoms on the leaves comparing to the control (untreated plants). The score of herbicide tolerance was recorded five weeks after spray (Figure 1). The most toxic herbicide was Paraquat 276 g a.i/ha followed by Imazethapyr. The results identified 9% and 1% of the genotypes were found highly tolerant (toxic symptoms <5%) to both herbicides (Imazethapyr 75 g a.i/ha; Metribuzin 175 g, respectively).


Number of Genotype
100
80
60
40
20
0
Imazethapyr 75 g a.i/ha
Metribuzin 175 g a.i/ha
Paraquat 276g a.i/ha
0-5
6-15
16-25
26-50
51-75
76-100
% of symptoms
Average % of toxic symptoms
60
50
40
30
20
10
0
Imazethapyr 75 g a.i/ha
Metribuzin 175 g a.i/ha
Paraquat 276g a.i/ha

Activity 8: Weed management in lentil

Title	**:**	Efficacy of pre- and post-emergence herbicides for weed control in lentil fields
Objectives	**:**	Study the efficacy of pre- and post-emergence herbicide for weed control Develop the integrated weed management module in lentil
Activities	**:**	New
Expected outcomes	**:**	Effective and economic doses of herbicide identified Integrated weed management modules developed
Observations to be taken	**:**	Crop phenology Growth and yield attributes Phytotoxic effect score (1-5) Chlorophyll content and NDVI Weed density and dry weight m^{-2} Weed control efficiency Weed index
Variety	**:**	Bakria
Results	**:**	Application of double dose of Metribuzin (350 g a.i/ha) observed lower weed density followed by application of Pendimethalin + Imazethapyr (Table 1). But these herbicides shown phytotoxic effect that affected the final yield. With respect to crop yield and weed control efficiency, the higher values were observed with Pendimethalin + Fluazifop-P-butyl treatment in lentil.

Table 1: Weed density as influenced by herbicides application in lentil fields

Treatments	Weed density		
	BLW	GRW	Total
T1 = Pendimethaline @ 1.0 kg a.i./ha (PE)	23	7	30
T2 = Imazethapyr @ 75 g a.i/ha (PoE)	27	5	32
T3 = Imazethapyr @ 150 g a.i/ha (PoE)	12	3	15
T4 = Pendimethaline @ 1.0 kg a.i./ha (PE) + Imazethapyr @ 75 g a.i/ha (PoE)	10	3	14
T5 = Metribuzin 175 g a.i/ha (PoE)	17	2	19
T6 = Metribuzin 350 g a.i/ha (PoE)	3	3	6
T7 = Pendimethali @ 1. 0 kg a.i/ha (PE) + Metribuzin 175 g a.i/ha (PoE)	18	2	20
T8 = Pendimethaline @ 1.0 kg a.i./ha (PE) + Fusilade (PoE)	19	0	19
T9 = Weed free	16	1	16
T10 = Weedy check	75	18	93

*BLW: broad leaves weeds; GRW: Grassy weeds; PE: Pre-emergence; PoE: Post-emergence

1. **Activity : Weed management in winter and spring chickpea**

Title	**:**	Efficacy of pre- and post-emergence herbicides for weed control in winter and spring chickpea
Objectives	**:**	Validate the results of efficacy of pre- and post-emergence herbicide for weed control

		Study the weed flora in winter and spring chickpea Develop of integrated weed management modules
Activities	**:**	Continued
Expected outcomes	**:**	Effective and economic doses of herbicide for weed control identified Integrated weed management modules developed for winter and spring chickpea
Observations to be taken	**:**	Crop phenology Growth and yield attributes Phytotoxic effect score (1-5) Chlorophyll content and NDVI Weed density and dry weight m^{-2} Weed control efficiency Weed index
Variety	**:**	Farihane
Results	**:**	The close proximity of weeds and their number cause suboptimal absorption of growth factors resulting in reduction of crop growth and yield. The major weed flora was observed during winter than spring. Results observed that herbicide application considerably increased chickpea yields when compared to the weedy check. Of the herbicide combinations being tested, Pendimethalin @ 1 kg a.i/ha + Fluazifop-P-butyl @ 120 g a.i./ha was identified as the most effective herbicide combination for weed control in chickpea. However, a phytotoxic effect of Imazethapyr was observed in both season. Further research involving higher plant densities and supplemental weed control using the herbicide, Fluazifop-P-butyl in conjunction with other pre- and post-emergence herbicides would provide valid conclusions in this current study.  Picture 1: General view of the experiment