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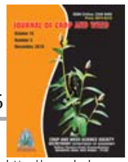

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Evaluation of the efficacy of pre and post emergence herbicides to manage grassy and broad leaf weeds on mungbean(*Vignaradiata* L.) in Western Tigray

ZENAWIGEBREGERGIS, FISEHABARAKI AND GEBREKI ROSMARU

Tigray Agricultural Research Institute, Humera Agricultural Research Center
P. O. Box 62, Humera, Ethiopia

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ABSTRACT

Mungbean (Vignaradiata) is a pulse crop, which is protein rich grown in the low lands. The objective to evaluate PRE and POST emergence herbicides on controlling grassy and broad leaf weeds in mungbean. Various types of herbicides (sharoxy, pendimethalin and quizalofop) at different rates (1, 2, 3 and 4 l/ha) including hand weeding and weedy check were studied for weed control and yield of mungbeanin the testing sites of Humera Agricultural Research Center in two locations during the year of 2018 autumn season under irrigation condition. Commelina Foecunda (Maimaio), Corchorusfascicularis L. (Hamiray), Sorghum halepense (Adar), were some of the major weeds recorded. All rates of sharoxy scored no weeds in Niguara and little weeds in Kebabo. Pendimethalin @ 2, 3, 4 l/ha has scored less weeds in Kebabo. Only quizalofop @ 1 l/ha and the weedy check had scored higher fresh weed biomass in Niguara, while the others were significantly similar with the hand weeding. Lower weed density and fresh weed biomass has scored from all sharoxy application rates, pendimethalin @ 2 l/ha and the hand weeded treatment. Higher grain yield has recorded from the application of pendimethalin @ 2 l/ha followed by the hand weeding. Quizalofop @ 2 l/ha and sharoxy @ 1 and 2 l/ha were statically similar with pendimethalin @ 2 l/ha, which produced better economic yield, low crop injuries and good weed control efficiencies. Therefore, sharoxy @ 1.5 l/ha, pendimethalin @ 2 l/ha and quizalofop @ 2 l/ha could be best weed control options in Mungbean production in western Tigray.

***Keywords*:** Efficacy, vigna radiate, weed management

Mungbean(*Vignaradiata* L.) which is also known as Green gram is classified in the Order Leguminosae (Verdcourt, 1970). It is an important pulse and protein rich crop in the world. Locally it is also known as "*Masho, Kotsalater and/orZerikeshisisay*". The crop plays a vital role in human diet by meeting protein requirements and improving fertility status of the soil. It is obvious that the lowland of northwestern Ethiopia is highly dominated by sesame and sorghum cultivation. Moreover, this mono cropping practice affects negatively soil fertility. Hence, this crop is indispensably important to use as a rotational crop. Another important character of this crop is its earliness to maturity and that can give reasonable yield even in the low rainfall areas. its short maturity duration (<60 days) make the crop ideal for catch cropping, intercropping and relay cropping. In addition, the forage remaining from mungbean after the pods has been picked and threshed is highly important for animal feed. The nutritive value of mungbean lies in its high and easily digestible protein, and contain approximately 25-28% protein,1.0% oil, 3.5-4.5% fiber, 4.5-5.5% ash and 62-65% carbohydrates on dry weight basis (Gowda *et al*., 2015). In Ethiopia, mungbean is produced in several parts of the country. Farmers in moisture stress areas of Southern Ethiopia(Gofa, Konso, South Omo zone and Konta), in Amhara (Shewarobit), Tigray (Western, North Western and Central Zones) and in some parts of Oromyahave producing to supplement their protein needs (Fiseha and Gebrelibanos, 2018).In some cases,mungbean is produced to compensate crop failure due to moisture deficit.There are number of constraints that limit the production of mungbean in the lowlands of western Tigray, like weeds, insect infestations, shattering, difference in pod maturity and indeterminate growths. Weed infestation is one of the major factors limiting the yield of Mungbean. Uncontrolled weeds may reduce mungbean yield as much as 50-90% compared with weed free (Poehlman, 1991 cited by (Khaliq *et al*., 2002)). Furthermore, although the magnitude of loss varies with the intensity and type of weed flora, Khan *et al*. (2011) reported that weeds cause 30-50% losses in the grain yield of mungbean and the critical period of crop-weed competition in mungbean varies from 15-30 days after sowing (DAS)). In western Tigray where this study has conducted, early weed infestations up to four weeks after emergence can cause up 80% yield losses in sesame (Mizan, 2011). The conventional practice to remove weeds in mungbean fields in western Tigray is hand weeding and it is too tedious and labor intensive. Now days, labor availability is notorious issues. The labor availability is decreasing from time to time, where the production cost is increasing from time to time. Generally, the current study has several advantages on; production cost reduction, labor minimization, productivity increment and it minimizes the duration of

Email : rehmanbau@gmail.com

fieldwork. Therefore, this work is designed objective to evaluate PRE and POST emergence herbicides on controlling grassy and broad leaf weeds in mungbean.

MATERIALS AND METHODS

A field experiment to evaluate effects of PRE and POST emergence herbicides on controlling grassy and broad leaf weeds of mungbean was conducted in western Tigray at two locations called Kebabo and Niguara during the year 2018 of autumn season under irrigation condition. The agro-ecology of the location is generally described as hot to warm semiarid plain having vertisol soil type; Kebabo with annual rainfall of 620-1132 mm, mean monthly temperature of 26-31^{o}c and an altitude of 670 m and Niguara with annual rainfall of 600-725 mm, mean monthly temperature of 27-30^{o}c and an altitude of 590m.

The experiment was conducted in split plot design having three replications. The path between blocks, main plots and sub-plots were 2, 2 and 1 m, respectively. Herbicides were allocated to main plots, where the application rates were assigned to sub-plots.The net plot area was 16 m^2. A variety called Arkebe was used and seeds were planted inspacing of 40 cm inter-row and 10 cm intra-row spacing.

Three different herbicides were used for the evaluation. The two herbicides pendimethalin 33% ecand sharoxy are PRE-emergence, *i.e*. they have applied before the crop was emerged; while the remaining one, called quizalofop-p-ethyl 15% ecwasa POST herbicide, sprayed two weeks after crop emergence. Hand weeding (at 15 and 30 days after crop emergence) and weedy check (untreated)were also usedas checks.

All the herbicides (pendimethalin 33% ec,quizalofop-p-ethyl 15% ecand sharoxy)were applied at four different rates (1, 2, 3 and 4 l/ha). Hand knapsack sprayer fitted with flat fan nozzle was used for the herbicide applications. When spraying, 600 liter of water per hectare was used to spray the herbicides.

All agronomic data (days to maturity, plant height, no. of branches, no. of pods per plant, no. of seeds per pod, yield kg/ha); stand count per meter square, weed density per meter square, fresh weed biomass per meter square and crop injury were collected in both locations.The injury score was recorded two times at 13 and 27 day after crop emergence based on Rao (2000) qualitative description of herbicide effects on crops in the visual cropping scales of 0-10. (0 = no injury, 1= slight stunting, discoloration, 2 = some stand loss, discoloration, 3=pronounced injury, but not persistent, 4=moderate injury, recovery possible, 5 = more injury, recovery doubt full, 6 = near severe injury, 7 = severe injury, stand loss, 8 = destroying, few plant survived, 9 = very few plant survived and 10 = complete crop failure)

RESULTS AND DISCUSSION

Weed abundance and dominance

Commelina Foecunda (Maimaio), *Corchorusfascicularis* L. (Hamiray), S*orghum halepense* (Adar), *Rahynochosiamalacophylla* (Teken), *Dinebraretroflexa* (Chwchwit), *Ipomoea spp* (Hareg), Wazwazo, ChiraWea'g, *Lactucaserriola* (Demaito), Saeriwayane were recorded as major weeds in the area (Fig. 1). When the abundance and dominance for the weeds grown in the experimental area were calculated, *Commelina Foecunda* (maimaio) scored the higher values (160 and 93.5%) for both abundance and dominance respectively, while all the remaining weeds scored low abundance and dominance (Fig. 1). A survey conducted in sesame farms of western Tigray showed that about 91.7% infestations with *C. foecunda* (Zenawi *et al*., 2018). The same authors found that 53.7 and 859 weeds/m^2 of *C. foecunda* abundance and density, respectively.

Efficacy of the herbicides to manage weeds on mungbean

There was statistically significant difference among the different herbicides and application rates in weed density and fresh weed biomass in both Kebabo and Niguara testing locations (p=0.05). The lower weed density (10-30 weeds m^{-2}) was recorded from sharoxy (@ all rates), while pendimethalin @ 1 l ha^{-1}, quizalofop (@ all rates) and the weedy check scored higher weed density in Kebabo.Similarly, sharoxy at all application rates and the hand weeding scored no weeds at all, while quizalofop@ 1 l ha^{-1} and the weedy check scored higher weed density and fresh weed biomass in Niguara (table 1). In Niguara experimental site application of sharoxy at different rates was incredibly effective in controlling the weeds and no weeds were observed in the plots. This indicated that sharoxy is much more effective in controlling weeds. Generally, sharoxy, pendimethalin and quizalofop have good weed controlling efficiency as the same as the hand weeding. Although Pendimethalin30 EC @ 1L a.i ha^{-1} was found best in management of weeds and both Quizalfop ethyl and Imazethapyr performed better than the control in weed control (Choudhary and Prakash, 2018). Most of the herbicides (Quizalofop-p-ethyl, Pendamethalin, Imazethapyr, Fenoxaprop-p-ethyl…) were found effective in controlling weeds and they were at par with hand weeding twice at 20 and 40 DAS in seed yield of green gram (Tamang *et al*., 2015). The same authors added that maximum benefit: cost ratio was obtained

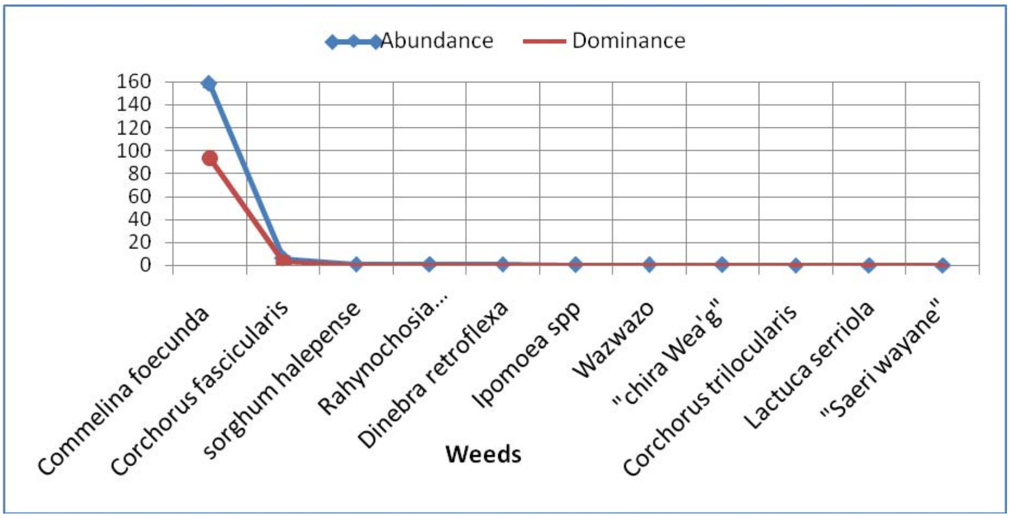

Fig.1. Weed abundance and dominance

from Vellore 32(Pendimethalin 30 EC+Imazethapyr 2 EC) @1 kg a.i ha^{-1}. Similarly, this finding showed that application of sharoxy (@ all rates), pendimethalin@ 2 l. ha^{-1} and quizalofop @ 2 l ha^{-1} were as effective as the hand weeding. The combined mean of the herbicides showed that there were statistical difference among the herbicides, regardless of their rates; in the weed density per meter square and fresh weed biomass per meter square(p=0.05). The lower weed density (9 weeds m^{-2}) and fresh weed biomass (10 g m^{-2}) were recorded from the application of sharoxy and it was statically similar with the hand-weeding (Table 2).

The interaction effects of the herbicides and application rates also showed highly significant difference on weed density and fresh weed biomass. Lower weed density and fresh weed biomass has scored from sharoxy@ all application rates, Pendimethalin @ 2l ha^{-1} and the hand weeded treatment, where the remaining treatments were not statistically different from the weedy check (table 3). According to Gentry (2010) Imazethapyr, Trifluralin, Pendimethaline and Quizalofop-P-ethyl are among some of the herbicides registered for mungbean weed control in India. Unrestricted weed growth significantly reduced sunflower seed yield by up to 42% but the herbicide oxyfluorfen (Sharoxy 24% EC) can significantly reduced the weeds (Osman *et al*., 2014). And Sharoxy alone or in mixture with Diuron irrespective of supplementary weeding displayed moderate to excellent weed control (Mubarak *et al*., 2006). Moreover, Khan *et al*. (2011) reported that 1090 kg/ha of mungbean yield was recorded from the application of pendimethalin at 2 litre ha^{1}. Nelson and Renner (1998) reported also quizalofop application resulted in less weed biomass and greater soybean yields.

Herbicides effects on yield and yield components of mungbean

Regarding the stand count perm^{2}, pods plant^{-1} and yield; there was statistically significant difference among the treatments (p=0.05). Higher number of pods plant^{-1} (17.7) was recorded from sharoxy treated plots, while all the remaining was statically similar. The higher yield (1006 kg ha^{-1}) was obtained from the hand weeding and there was no statistical significant difference in the yield among the three herbicides and the hand weeding check. Lower stand count (28.3 m^{-2}) was scored on shoroxy treated plot, while pendimethalin, quizalofop and both the checks scored statically similar higher stand count (>30 m^{-2}), which enabled them to bear higher yield (Table2). Although sharoxy treated plot has lower plant stands per meter square but its yield score was statistically similar with pendimethalin and quizalofop treated plots. Perhaps it could be as expense of the higher number of pods plant^{-1}, which might compensate the stand losses. Pendimethaline and Imazethapyr are the most effective herbicides for weed control and yield enhancements in mungbean(Tamang *et al*., 2015, Khairnar *et al*., 2014). Similarly, Khan *et al*. (2011) reported that 1090 kg ha^{-1} of mungbean yield was recorded from the application of pendimethalin at a rate of 2 litter ha^{-1}.

Interaction effect of the herbicides and application rates on yield and yield components of Mungbean

There was significant difference in plant height, pods plant^{-1}, stand count and yield among the interaction herbicides and their application rates (p=0.05). The longer stature (41.17 cm) was recorded from the application of sharoxy@1l ha^{-1}, while shorter (32.3 cm) was recorded from quizalofop@ 4 l ha^{-1} and it was

Table 1: Weed density, biomass and mungbean yield as influenced by the different herbicide types and rates across locations

Herbicide	Application rates ($l.ha^{-1}$)	Weed density ($weeds.m^{-2}$)		Fresh weed biomass ($g.m^{-2}$)		seed yield ($kg.ha^{-1}$)	
		Kebabo	Niguara	Kebabo	Niguara	Kebabo	Niguara
Pendimethalin	1	102	357	536	75	1359	234
	2	52	351	276	72	1751	283
	3	38	423	341	120	1033	267
	4	27	634	277	105	1657	284
Quizalofos	1	105	658	239	412	1674	205
	2	75	598	389	196	1498	231
	3	86	478	487	162	1563	246
	4	116	428	390	151	1179	195
Sharoxy	1	31	0	82	0	1556	181
	2	21	0	45	0	1124	305
	3	10	0	13	0	1023	244
	4	10	0	24	0	1177	170
Checks	**Hand**	58	0	22	0	1708	304
	weeding	197	355	428	221.3	1159	161
Grand mean		**59.0**	**306.0**	**252**	**101.0**	**1404.0**	**250.60**
SE(±)		**29.2**	**182.1**	**150**	**125.3**	**371.4**	**61.97**
CV%		**49.4**	**59.5**	**59**	**124**	**26.4**	**24.70**
LSD (0.05)		**38.7**	**241.6**	**199**	**166.3**	**NS**	**82.22**

Table 2: Weed biomass, weed density, yield and yield components of mungbean as affected by the application of the herbicides

Herbicides	No.of Pods ($plant^{-1}$)	Plant population ($plant\ m^{-2}$)	Seed yield $kg\ ha^{-1}$	Weed density ($weeds\ m^{-2}$)	Fresh weed biomass (gm^{-2})
Pendimethalin	12.05	30.65	859	248	225
Quizalofop	10.17	33.75	849	318	303
Sharoxy	17.68	28.34	723	8.9	20.5
Hand weeding	10.67	32.25	1006	29	11
weedy	11.73	33.89	780	226	275
Grand mean	13	31.2	827	182	177
SE (±)	**4.751**	**7.57**	**264**	**138**	**153**
LSD (0.05)	**4.35**	**6.93**	**242**	**126**	**140**

statistically similar with all the remaining treatments including the checks. All the treatments were statistically similar in plant height with hand weeding treatment, meaning the herbicides have no adverse effects on the plant growth nature. Fiseha and Gebrelibanos (2018) reported that the higher plant height of mungbean was found 42.2 cm from agronomic study with no herbicide application.

Regarding the number of pods $plant^{-1}$, it was statistically significant among the treatments (p=0.05). The higher number of pods $plant^{-1}$ (14-20 pods $plant^{-1}$) was recorded from sharoxy at the application rates of 1, 2, 3 and 4 l ha^{-1} and pendimethalin @ 4 l ha^{-1}. In contrast lower (9-11 pods $plant^{-1}$) was recorded on of quizalofop@ 1, 2, 3, 4 l ha^{-1} and it was statistically non-significant with pendimethalin @ 1, 3 l ha^{-1} and the hand weeding. Pendimethalin @ 2 l ha^{-1} was significantly similar with all sharoxy sprayed plots. The lower number of pods (quizalofop) might be associated with scorching or burning effect of the herbicides when applied at higher dose and with low control efficiency when applied at lower doses. As mentioned in the methodology part, quizalofop is a POST herbicide, which was applied two weeks after crop emergence.

Table 3: Weed density, biomass, yield and yield components of mungbean as affected by the interaction effect of the hrbicides and application rates

Herbicides	Application rates (l ha^{-1})	Plant height cm	No.of pods plant^{-1}	Plant population (plants m^{-2})	Seed yield (kg ha^{-1} a)	Weed density (weeds m^{-2})	Fresh weed biomass (g m^{-2})
Pendimethalin	1	35.5	11.6	32.5	797	229	306
	2	35.0	12.4	31.5	1017	201	174
	3	32.8	9.9	28.2	650	231	230
	4	37.3	14.3	30.4	970	331	191
Quizalofop	1	35.2	9.8	34.7	749	382	326
	2	31.6	11.2	33.9	864	336	293
	3	37.6	10.5	32.9	904	282	325
	4	32.3	9.2	33.5	687	272	271
Sharoxy	1	41.2	15.4	29.8	868	15.5	41
	2	39.5	18.9	34.5	715	10.5	22.7
	3	35.2	16.2	25.8	654	4.8	6.7
	4	35.9	20.1	23.2	674	4.8	11.8
Checks	Hand weeding	33.6	10.7	32.3	1006	29	11
		37.3	11.7	33.9	629	376	335
Grand mean		**35.7**	**13.0**	**31.20**	**827**	**182**	**177**
SE (±)		**5.1**	**4.8**	**7.57**	**264**	**138**	**153**
LSD (0.05)		**4.7**	**4.4**	**6.93**	**242**	**126**	**140**

Table 4: Crop injury scores of mungbean at 13 and 27 days after emergence

Herbicide	Application rates (l ha^{-1})	Crop injury score @ 13DAE (0-10)	Crop injury score @ 27DAE (0-10)
Pendimethalin	1	0.5	0.5
	2	0.5	0.5
	3	1.0	0.5
	4	2.0	0.5
Quizalofop	1	0.0	2.0
	2	0.0	2.2
	3	0.0	2.7
	4	0.0	2.7
Sharoxy	1	2.5	1.0
	2	2.3	1.0
	3	3.5	1.0
	4	3.8	1.0
Checks	Hand weeding	0.0	0.0
		0.0	0.0
Grand mean		**1.15**	**1.13**
SE(±)		**0.80**	**0.65**
CV (%)		**69.50**	**57.50**
LSD (0.05)		**0.73**	**0.59**

Scores; 0=no injury, 1=slight stunting or discoloration, 2=some stand loss, stunting, 3=injury more pronounced but not persistent, 4=moderate injury, recovery possible, 5=injury more persistent, recovery doubtful, 6= injury more persistent, no recovery…., 10=complete failure.

When we detect the yield response of the crop, it was found statistically significant among the interaction effect of the herbicides and application rates (p=0.05%). The higher grain yield (1017 kg ha^{-1}) was recorded from the application of pendimethalin@ 2 l ha^{-1} followed by hand weeding (1006 kg ha^{-1}).On the other side lower yield (629 kg ha^{-1}) was recorded on the weedy check. In addition, sharoxy@ 3, 4 l ha^{-1}, pendimethalin 3 l ha^{-1} and quizalofop@ 4 l ha^{-1} have scored low grain yields next to the weedy check (Table 3). Kaur *et al.* (2009) reported that 1447 kg ha^{-1} of mungbean yield was obtained from the application of Pendimethalin@ 0.75 kg ha^{-1}. Furthermore, Khan *et al*. (2011) reported 1090 kg ha^{-1} of mungbean yield was recorded from the application of pendimethalin at a rate of 2 litre ha^{-1}. Hence, our finding is in line with the findings of khan *et al.* (2011) in terms of mungbean yield. Moreover, application of oxyfluorfen (Sharoxy 24% EC), significantly increased grain yield of sunflower (by up to 42%) in comparison to the unweeded treatment (Osman *et al*., 2014). Similarly, POST herbicide (quizalofop) resulted in less weed biomass and greater soybean yields (Nelson and Renner, 1998).

Regarding to herbicide residues; several research results showed that the herbicides are not persistent in the soil and in the grains as well. No residues of oxyfluorfen (sharoxy) were detected in treated and control samples of sunflower (Osman *et al*., 2014). Similarly, no metribuzin and quizalofop-pethyl residues (0.01 g kg^{-1}) were detected in potato at harvest time with holding period of 2.5 months after the pesticides application and the half-life times (t1/2) of the pesticides in soil was 6.28 and 2.06 days, respectively(Hu *et al*., 2010). Sondhia (2012)stated also that low or below standard pendimethalin residues was found in chickpea grain (<0.02ìg/g). The same author added that the dissipation of pendimethalin in the crop field soil has half-life of 11 days. Likewise, pendimethalin residues in field pea were found below the maximum residue limit (0.05 µg g”1) and residues in soil were also below the detection limits (Sondhia, 2013).

Crop injuries

The analysis of variance showed that significant difference on both crop injuries at 13 and 27 days after emergence (p=0.05) (Table4). Lower injury level was scored on pendimethalin@ all rates, sharoxy @ 1, 2 l ha^{-1}and quizalofop@ all rates at 13DAE, while higher level of crop injury was scored on sharoxy @ 3, 4 l ha^{1} sprayed plots. A maximum injury at 27DAE was scored on quizalofop@ 3, 4 l/ha sprayed plot; while pendimethalin@ all rates and sharoxy @ all rates were significantly similar with unsprayed plots. Plants in the sharoxy sprayed plot were showed slight stunting and some discolorations but were not persistent. Quizalofop sprayed plots showed scorching symptoms at 27 DAE not 13 DAE, because quizalofop was sprayed 14 DAE. PREemergence herbicides showed less injury and fast recovery compared to POSTemergence herbicide but still all the herbicides were better than the unsprayed (control). This study was in line with Soltani *et al*. (2013) that crop injury was generally greater at the 2X rate compared to the 1X rate for each herbicide evaluated and decreased over time. Higher rates of PREemergence herbicides like chlorambem, linuron, and alachlor showed relatively low phytotoxicity and even POST emergence herbicides, acifluorfen (300 g, a.i ha^{-1}) showed the best weeding efficacy with no yield reduction though some phytotoxicity which recovered within 20 days(Hong *et al*., 1983). Moreover, weed control efficiency and the value of mungbean agronomic traits has increased significantly through application 1 kg ha^{-1} pendimethalin compared to the weedy check (Srinivasan *et al*., 1990). Generally, sharoxy @ 1, 2 l ha^{-1}, pendimethalin @ 2 l ha^{-1} and quizalofop @ 2 l ha^{-1} had no severe crop injuries and had good weed control efficiencies.

CommelinaFoecunda (Maimaio), *Corchorus fascicularis* L. (Hamiray), *Sorghum halepense* (Adar), *Rahynochosiamalacophylla* (Teken), *Dinebraretroflexa* (Chwchwit) are the most abundant weeds in the area. All rates of sharoxy scored no weeds in Niguara and little weeds in Kebabo. Pendimethalin @ 2, 3, 4 l ha^{-1} has scored less weeds compared to the weedy check in Kebabo. Only quizalofop @ 1 l ha^{-1} and the weedy check had scored higher fresh weed biomass in Niguara, while the others were significantly similar with the hand weeding. Lower weed density and fresh weed biomass has scored from all sharoxy application rates and pendimethalin @ 2 l ha^{-1}, which were significantly similar with the hand weeded treatment. Higher grain yield was recorded from the application of pendimethalin @ 2 l ha^{-1} followed by hand weeding. Quizalofop@ 2 l ha^{-1} and sharoxy @ 1, 2 l ha^{-1} were statistically similar with pendimethalin @ 2 l ha^{-1}, which produced better economic yield, low crop injuries and good weed control efficiencies . Therefore, sharoxy @ 1.5 l ha^{-1}, pendimethalin @ 2 l ha^{-1} and quizalofop @ 2 l ha^{-1} could be best weed control options in mungbean production.

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