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Herbicidal effect of imazethapyr and chlorimurin ethyl on yield parameters of green gram (*Vigna radiata* L.)

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Abstract
The experiment was conducted during kharif, 2015 and 2017 at Agricultural Research Station, Madhira farm, Professor Jayashankar Telangana Agricultural University, Hyderabad (Telangana). The experimental soil was low in available N, medium in P and High in K. The experiment was laid out as RBD with three replications comprising eleven treatments viz., pendimethalin 1.0 kg ha-1 as pre emergence (PE), imazethapyr 50 g ha-1 at 2-3 weed leaf stage (WLS), chlorimuron ethyl 3.5 g ha-1 (PE), imazethapyr 70 g ha-1 (PE) fb quizalofop ethyl 50 g ha-1 (2-3 WLS), imazethapyr 80 g ha-1 (PE) fb quizalofop ethyl 50 g ha-1 (2-3 WLS), chlorimuron ethyl 3.5 g ha-1 (PE) fb imazethapyr 70 g ha-1 (2-3 WLS), chlorimuron ethyl 3.5 g ha-1 (PE) fb imazethapyr 80 g ha-1 (2-3 WLS), chlorimuron ethyl 2.5 g ha-1 (PE) fb imazethapyr 70 g ha-1 (2-3 WLS), chlorimuron ethyl 2.5 g ha-1 (PE) fb imazethapyr 80 g ha-1 (2-3 WLS), hand weeding twice at 15 and 30 DAS and weedy check (untreated control). Weed control treatments resulted as increased in grain yield than weedy check. Hand weeding twice at 15 and 30 DAS, imazethapyr 70 g ha-1 (PE) fb quizalofop ethyl 50 g ha-1 (2-3 WLS) and chlorimuron ethyl 2.5 g ha-1 (PE) fb imazethapyr 70 g ha-1 (2-3 WLS) recorded better yields in greengram.

Keywords: pre emergence, weed leaf stage, imazethapyr, chlorimuron ethyl, harvest index

Introduction
Green gram (*Vigna radiata* L.) has been grown in India since ancient times. It is also known as mungbean and golden gram. It is important short duration, predominantly rainy season pulse crop grown in many part of India. Green gram reported to be originated in India. India is producing 19 lakh tons of greengram from an area of 41 lakh hectare. In Telangana, greengram production of 0.65 lakh tons from an area of 0.99 lakh hectares. Green gram is grown widely for use as a human food. Largely consumed as dal in India, it is supposed to be easily digestible. It contains about 25 % protein, 60 % carbohydrate, 1.3 % fat and several essential amino acid including lysine, which is generally found deficient in cereals and providing protein rich diet to vegetarian population of the country. It is also rich in Vitamin A, B1, B2 C and calcium, phosphorus and potassium (Singh, 1998) [14]. It plays an important role not only in human diet, but also in improving the soil fertility through biological nitrogen fixation with Rhyzobium (Upadhyay *et al*. 1999) [18].

However, about 2-3 million tons of pulses are imported annually to meet the domestic consumption requirement. Thus, there is need to increase production and productivity of pulses in the country by more intensive interventions. Green gram is grown as rainfed or irrigated condition in wider rows. Cultural and mechanical weed control can be practiced, but it is not always feasible due to their high cost, non availability of labour at appropriate time, prevailing weather condition, long window of weed emergence in the growing season and continuous moisture during rainy season is a problem which make it difficult to remove within specified time when they are most potent of injury to crop. So chemical methods of weed management offer good scope for harvesting a good crop of green gram. Weed infestation is one of the major constraints in green gram cultivation. In view of severe infestation of annual and perennial weeds in green gram, the potential yield is generally not realized. As weeds compete for nutrient, water, light and space with crop plant during early growth period in turn yield losses in green gram due to weeds have been estimated to range between 30-50 %. Annual broad leaf weeds germinates at the same time as green gram and complete its life cycle

within 60 days (Balyan, 1985) [5] and grassy weed germinate immediately after onset of rains and irrigation. If not controlled at proper time, can cause heavy yield losses. The extent of yield reduction due to weeds in green gram have been reported to be 42-68% (Patro and Prusty, 1994, Singh *et al.*, 1995) [12, 15] depending upon intensity and type of weed flora. Thus it is necessary to eliminate weeds from crop at proper time and with suitable methods.

The most commonly used herbicides for controlling weeds in green gram are pendimethalin, alachlor and fluchloralin (Mishra and Singh, 1993) [10]. Recently, imazethapyr, a new imidazolinone herbicide, has been introduced for the control of complex weed flora in pulse crops like blackgram and lentil (Duary *et al.*, 2016; Singh *et al.*, 2014) [8, 13]. Imazethapyr can be applied as pre-plant incorporation, pre-emergence, and post-emergence to control grasses and broadleaved weeds in pulse crops (Anonymous 2006) [3] application of imazethapyr at 40-75 g ha-1 proved to be effective herbicide in kharif green gram replacing pendimethalin across the zones (Anonymous 2011) [4]. The information on testing of chlorimuron ethyl to control the weeds in greengram is meager under black soils in Telangana. Hence, the present study was under taken to evaluate the effect of herbicides on yield parameters in greengram.

Materials and Methods

The experiment was carried out at the Agricultural Research Station, Madhira farm of Professor Jayashankar Telangana Agricultural University, Hyderabad (Telangana) during kharif, 2015 and 2017. The experimental field is located at latitude of 16.92′ north and longitude of 80.36′ east and at an altitude of 38 meters above the mean sea level. The soil of the experimental field was clay loam soil in texture, having alkaline reaction (pH=8.3), EC=0.33 ds m-1, low organic carbon (0.18%) and having low available nitrogen (153 kg ha-1), medium in available phosphorus (42 kg ha-1) and high in available potassium (538 kg ha-1). The experiment comprising of eleven treatments was laid out in randomized block design with three replications. The treatments were pendimethalin @ 1.0 kg ha-1 as pre emergence (PE), imazethapyr @ 50 g ha-1 at 2-3 weed leaf stage (WLS), chlorimuron ethyl @ 3.5 g ha-1 as PE, imazethapyr @ 70 g ha-1 as PE followed by (fb) quizalofop ethyl @ 50 g ha-1 at 2-3 WLS, imazethapyr @ 80 g ha-1 as PE fb quizalofop ethyl @ 50 g ha-1 at 2-3 WLS, chlorimuron ethyl @ 3.5 g ha-1 as PE fb imazethapyr @ 70 g ha-1 at 2-3 WLS, chlorimuron ethyl @ 3.5 g ha-1 as PE fb imazethapyr @ 80 g ha-1 at 2-3 WLS, chlorimuron ethyl @ 2.5 g ha-1 as PE fb imazethapyr @ 70 g ha-1 at 2-3 WLS, chlorimuron ethyl @ 2.5 g ha-1 as PE fb imazethapyr @ 80 g ha-1 at 2-3 WLS, hand weeding twice at 15 and 30 days after sowing (DAS) and weedy check (untreated control). Seeds of greengram variety MGG-295 were sown on July 6, 2015 and July 7, 2017 at spacing of 30 cm X 10 cm in first and second year respectively. The recommended dose of fertilizers (20 kg N and 50 kg P2O5) applied as basal through Urea and di-ammonium phosphate (DAP). All other agronomic practices and plant protection measures were adopted to raise the crop. As per treatment schedule, the herbicides were applied uniformly in the experimental plots with the help of knapsack sprayer fitted with flat fan nozzle using a spray volume of 500 l ha-1. The grain, straw yield and harvest index recorded at harvest.

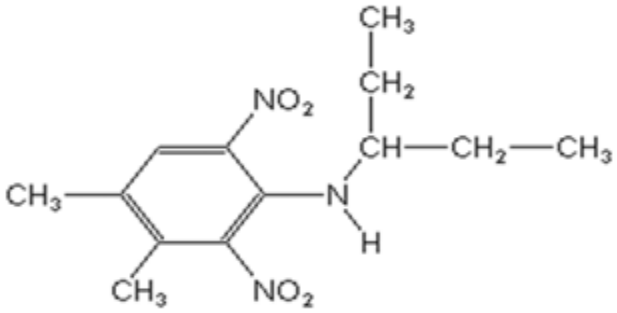
Table 1: Treatment details

Treatment number	Treatment detail
T_1	pendimethalin @ 1.0 kg ha^{-1} as pre emergence (PE)
T_2	imazethapyr @ 50 g ha^{-1} at 2-3 weed leaf stage (WLS)
T_3	chlorimuron ethyl @ 3.5 g ha^{-1} as pre emergence (PE)
T_4	imazethapyr @ 70 g ha^{-1} as PE fb quizalofop ethyl @ 50 g ha^{-1} at 2-3 WLS
T_5	imazethapyr @ 80 g ha^{-1} as PE fb quizalofop ethyl @ 50 g ha^{-1} at 2-3 WLS
T_6	chlorimuron ethyl @ 3.5 g ha^{-1} as PE fb imazethapyr @ 70 g ha^{-1} at 2-3 WLS
T_7	chlorimuron ethyl @ 3.5 g ha^{-1} as PE fb imazethapyr @ 80 g ha^{-1} at 2-3 WLS
T_8	chlorimuron ethyl @ 2.5 g ha^{-1} as PE fb imazethapyr @ 70 g ha^{-1} at 2-3 WLS
T_9	chlorimuron ethyl @ 2.5 g ha^{-1} as PE fb imazethapyr @ 80 g ha^{-1} at 2-3 WLS
T_{10}	Hand weeding twice at 15 and 30 DAS
T_{11}	Weedy check (Untreated check)

Mode of action of pendimethalin

It act both pre-emergence that is before weed seedling have emerged and early post emergence. Pendimethalin inhibits both cell division and cell elongation in the roots and shoot meristem of the susceptible plant. The growth is inhibited directly following absorption through hypocotyls and shoot region. Germination as such is not inhibited, the plant die shortly after germination or emergence from the soil.

Group	:	Dinitroaniline
Common name	:	Pendimethalin
Trade name	:	Stomp
Active ingredient	:	30% EC
IUPAC name	:	N-(1-ethylpropyl)-2, 6-dinitro-3, 4-xylidine
Empirical formula	:	$C_{13}H_{19}N_3O_4$
Structural formula	:	



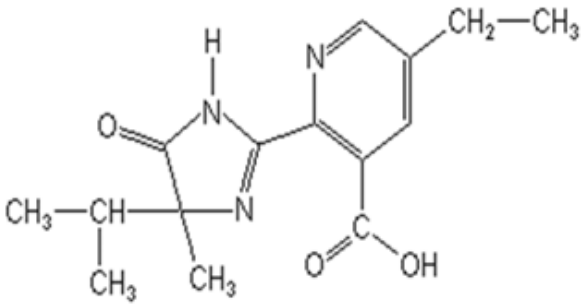
Mode of action of imazethapyr

It is absorbed by roots and foliage, trans-located throughout the xylem and phloem, and accumulated in the growing regions. Therefore, it controls the entire weeds and plants, including root or rhizome. It control both emerged and multiple flushes of shallow germination weeds. It kills the weed by inhibition of acetohydroxy acid. This causes a disruption in protein synthesis. It target the plastid enzyme acetolactate synthase (ALS) in plant, which catalyses the first

step in the biosynthesis of initial branched chain amino acids (valine, leucine and isoleucine). The ALS inhibitors thus stop cell division and reduce carbohydrate translocation in the susceptible plants. The affected plant succumbs to this herbicide completely in 7-20 days. After pre-emergence or pre plant incorporation susceptible weeds may germinate and emerge; however, normal growth stops. After post-emergence application susceptible weeds stop growing and necrosis occur within 4-8 days and provide control over 30 -35 DAS.

Group	:	Imidazolinone
Common name	:	Imazethapyr
Trade name	:	Pursuit
Active ingredient	:	10 % SL
IUPAC name	:	5-ethyl-2-[(RS)-4-isopropyl-4-methyl-5-oxo-2-imidazolin-2-yl] nicotinic acid
Empirical formula	:	$C_{15}H_{19}N_3O_3$

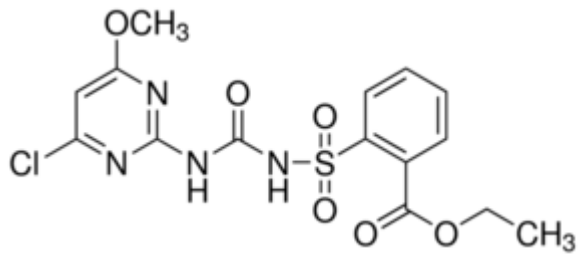
Structural formula:



Mode of action of chlorimuron ethyl

Sulfonylurea class herbicide that inhibits acetolactate synthase, which regulates plant growth. Branched chain amino acid synthesis (ASL or AHAS) inhibitor. Stops plants making amino acids leucine, isoleucine, valine, so many proteins can't be made. Growth stops within hours, stunting shoots and roots; leaves yellow and die over day to weeks. Control a broad spectrum of weeds in many different crops; post-emergence or pre-emergence.

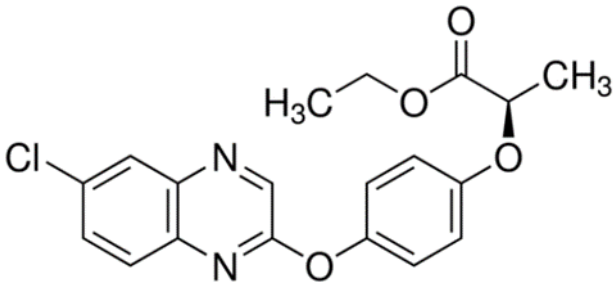
Group	:	Sulfonylurea
Common name	:	Chlorimuron-ethyl
Trade name	:	Kloben
Active ingredient	:	25% WP
IUPAC name	:	Ethyl 2-[(4-chloro-6-methoxypyrimidin-2-Yl) carbamoylsulfamoyl] benzoate
Empirical formula	:	$C_{15}H_{15}ClN_4O_6S$
Structural formula	:	



Mode of action of quizalofop-P-ethyl

It has specific activity against grass species only. Translocation of these herbicides can occur in both the xylem and the phloem, and all generally require the addition of an adjuvant to improve leaf coverage and absorption. These herbicides are most effective when applied to unstressed, rapidly growing grasses. Death of the grass is slow, requiring a week or more for complete kill. Symptoms include rapid cessation of shoot and root growth, pigment changes (purpling or reddening) on the leaves occurring within 2 to 4 days, followed by a progressive necrosis beginning at meristematic regions and spreading over the entire plant. These herbicides inhibit the enzyme acetyl-CoenzymeA carboxylase (ACCase) in the biosynthetic pathway leading to lipid biosynthesis in plants, preventing fatty acid formation, which is essential for plant lipid synthesis. Lack of lipids results in loss of cell integrity of membranes and no new growth.

Group	:	Aryloxyphenoxy-propionate
Common name	:	Quizalofop-P-ethyl
Trade name	:	Targa super
Active ingredient	:	5% EC
IUPAC name	:	Ethyl 2-[4-(6-chloroquinoxalin-2-Yl) oxyphenoxy] propanoate
Empirical formula	:	$C_{19}H_{17}ClN_2O_4$
Structural formula	:	



Grain yield (kg ha^{-1})

The weight of grains harvested from net plot area was recorded in Kg and finally expressed as kg ha^{-1}.

Straw yield (kg ha^{-1})

Straw yield from net plot area was computed by subtracting the grain yield from the biological yield and later converted into kg ha^{-1}.

Biological yield (kg ha^{-1})

After harvesting, the green gram crop was sun dried and then weight of net plot area harvested was recorded in Kg and expressed as kg ha^{-1}.

Harvest index (%)

The harvest index of Urdbean was obtained by dividing the economical yield (grain yield) with the biological yield (grain + straw) and represented in percentage (%).

$$\text{Harvest index} = \frac{\text{Economic yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})} \text{ X } 100$$

Results and discussion

Grain yield

The data revealed that all weed control treatments significantly increased the grain yield over weedy check (untreated control). The maximum grain yield (1364, 1260

and 1312 kg ha-1) was recorded in hand weeding twice at 15 and 30 DAS during 2015, 2017 and pooled respectively and it was significantly higher than other treatments. Among the herbicidal treatments, higher grain yield was recorded in treatments imazethapyr @ 70 g ha-1 applied as pre emergence followed by quizalofop ethyl @ 50 g ha-1 at 2-3 weed leaf stage (1273, 1182 and 1228 kg ha-1) and chlorimuron ethyl @ 2.5 g ha-1 applied as pre emergence followed by imazethapyr @ 70 g ha-1 at 2-3 weed leaf stage (1190, 964 and 1077 kg ha-1) during 2015, 2017 and pooled respectively. This might be due to broad spectrum weed control at critical stage of the crop.

Straw yield

Significantly increased straw yield recorded in weed control treatments over weedy check (untreated control). The highest straw yield (2434, 2129 and 2282 kg ha-1) was recorded in hand weeding twice at 15 and 30 DAS during 2015, 2017 and pooled respectively and it was significantly higher than other treatments. Among the herbicidal treatments, higher grain yield was recorded in treatments imazethapyr @ 70 g ha-1 applied as pre emergence followed by quizalofop ethyl @ 50 g ha-1 at 2-3 weed leaf stage (2195, 2032 and 2113 kg ha-1) and chlorimuron ethyl @ 2.5 g ha-1 applied as pre emergence followed by imazethapyr @ 70 g ha-1 at 2-3 weed leaf stage (2020, 1724 and 1872 kg ha-1) during 2015, 2017 and pooled respectively.

Biological yield

The data revealed that all weed control treatments significantly increased the straw yield over weedy check (untreated control). The highest straw yield (3798, 3389 and 3593 kg ha-1) was recorded in hand weeding twice at 15 and 30 DAS during 2015, 2017 and pooled respectively and it was significantly higher than other treatments. Among the herbicidal treatments, higher grain yield was recorded in treatments imazethapyr @ 70 g ha-1 applied as pre emergence followed by quizalofop ethyl @ 50 g ha-1 at 2-3 weed leaf stage (3468, 3214 and 3341 kg ha-1) and chlorimuron ethyl @ 2.5 g ha-1 applied as pre emergence followed by imazethapyr @ 70 g ha-1 at 2-3 weed leaf stage (3210, 2688 and 2949 kg ha-1) during 2015, 2017 and pooled respectively.

Harvest index

The harvest index recorded as 36.7 % in imazethapyr @ 70 g ha-1 applied as pre emergence followed by quizalofop ethyl @ 50 g ha-1 at 2-3 weed leaf stage and 37.1 % in chlorimuron ethyl @ 2.5 g ha-1 applied as pre emergence followed by imazethapyr @ 70 g ha-1 at 2-3 weed leaf stage during 2015. During 2017 and pooled data shown as non significant in harvest index of all weed control treatments.

Hand weeding twice at 15 and 30 DAS, imazethapyr @ 70 g ha-1 applied as pre emergence followed by quizalofop ethyl @ 50 g ha-1 at 2-3 weed leaf stage and chlorimuron ethyl @ 2.5 g ha-1 applied as pre emergence followed by imazethapyr @ 70 g ha-1 at 2-3 weed leaf stage during two years and pooled attributed to control the broad spectrum of weeds at early stage of the crop and maintenance of less weed population throughout the crop growth period as it persisted long enough to prevent emergence of weed. All these factors resulted in better availability of nutrient and moisture to the crop and less weed competition on the crop growth and yield contributing characters. Inturn resulted as higher grain yield, straw yield, biological yield and harvest index in greengram. These finding are supported by the results of Akhilesh *et al.* (2017) [1], Chin and Pandey (1991) [7], Tewari *et al.* (2004) [17], Charan Teja *et al.* (2017) [6], Narendra Kumar *et al.* (2016) [11], Ali *et al.* (2011) [2], Sukumar *et al.* (2018) [16] and Jagadesh *et al.* (2019) [9].

Conclusion

Weed management practices showed significant effect on grain yield, straw yield, biological yield and harvest index. Hand weeding twice at 15 and 30 DAS was found significantly superior to rest of the weed management practices. Herbicidal treatments imazethapyr @ 70 g ha-1 applied as PE followed by quizalofop ethyl @ 50 g ha-1 at 2-3 WLS and chlorimuron ethyl @ 2.5 g ha-1 applied as PE followed by imazethapyr @ 70 g ha-1 at 2-3 WLS shown better yield in greengram.

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