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Studies on chemical weed management in chickpea (*Cicer arietinum* L.): A review

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Abstract
In India Chickpea (*Cicer arietinum*) is one of the most essential pulse crop. It is a key source of protein. It plays an important role in human nutrition for large population in the developing world but its productivity is relatively low. There are lots of reasons for low productivity. Weed is the basic problem in all cereals as well as pulses. Weed control is the basic requirement of crop at below the economic threshold level. Chickpea is poor competitive crop with weeds because slow growth rate and development. It has limited branches and low leaf area weed competition of chickpea up to 60 days after sowing (Singh and Singh, 2000). Chickpea is highly susceptible to weed competition and the weeds causes 75% of yield losses (Chaudhary *et. al.* 2005). Considering the losses caused due to weeds, it is essential to manage the weeds within their critical crop-weed competition period.

Keywords: Chickpea, weed, weed flora, weed density, herbicide

Introduction
Pulses are an integral part of Indian agriculture. Chickpea (*Cicer arietinum* L.) commonly known as gram or Bengal gram belong from Fabaceae family. It's one of the most important rabbi season pulse crop grown in India for economic importance and maintaining soil fertility.
In India pulses are the second most important component of the diet after cereals. The net availability of food grains per capita increased day by day from 144.1 kg/year in 1951 to 179.6 kg/year in 2019 in spite of an growth in population however the net obtainability of pulses has reduced from 25 kg/year in 1961 to 17.5 kg/year in 2019 (Anonymous, 2020) [1]. Chickpea is poor competitive crop with weeds because slow growth rate and development. It has limited branches and low leaf area weed competition of chickpea up to 60 days after sowing (Singh and Singh, 2000) [33]. Chickpea is highly susceptible to weed competition and the weeds causes 75% of yield losses (Chaudhary al. et. 2005) [6]. In India annual losses of agriculture produce from weeds 45 percent, disease 20 percent, and insects 30 percent and other pests 3 percent. Weeds affects growth yield and quality of crop and reduce soil fertility. It's reduce soil moisture, nutrients, and competes for space and sunlight with crop. Weeds reduce the crop yield indirectly by serving as alternate host and number of crop pests, weeds species particularly *vicia sativa* weeds provide shelter to *Helicoverpa armigera* a major pests of chickpea. The weed management in chickpea is an important component of plant protection and improving production potential of the crop. Khan *et al.* (2011) Peshawar, Pakistan reported that most problematic weeds in chickpea crop and highest Weeds Germination in mid-February due to rainfall. The weed i.e. poa *annum* L., *Anagallis arvensis* L., *Ammi visanga* (L.) Lam. and *Euphoria helioscopia* L. were present in field.

Weed flora in chickpea
Weeds are serious problem in realizing successful chickpea production. For controlling weeds, detailed knowledge of the weed flora is acquired from the field. It is difficult to identify weed species during early stages which can be challenging since many species mimic crops. The first and foremost step for an effective weed management strategy is knowledge about weed flora of a specific locations. The weed species shifts the chickpea fields differ from one location to another depending on the agro-climatic situations in the country. At Parbhani, Maharashtra (Gore *et al., 2018*) [10]. Reported Among monocots *Echinochloa crusgalli* L, *Brachiria mutica*, and *Cyperus rotundus, Cynodon dactylon* L.; among sedges and dicots were *Amaranthus viridis* L., *Physalis minima, Digera arvensis, Euphorbia hirta,* and *Alternanthera*

sessilis Parthenium hysterophorus.
Yadav *et al.*, (2018) [40] at Jodhpur they reported during the *rabbi* season the field was infested with of *Chenopodium album Rumex dentatus* and *Chenopodium murale*, among these *Chenopodium murale* was the dominant weed species. Singh *et al.* (2016) At Varanasi in *rabbi* season field were infested with *Chenopodium album, Melilotus alba, Medicago hispida Cynodon dactylon*, and *Phalaris minor*.
Merga and Alemu (2019) [21] at Haramaya, Ethiopia. Reported that pre dominant weeds infesting the chickpea were *Medicago polymorpha, Solanum nigrum, Galinsoga parviflora, Parthenium hysterophorus, Commelina benghalensis*, and *Cyperus rotundus*.
Kakade (2020) [38] they reported that major weed flora during *rabbi* season in chickpea crop *Celosia argentea, Euphorbia geniculata, Tridex procumbance, Anagallis arvensis Argemone mexicana, Parthenium hysterophorus, Chenopodium album, Ipomea carnea*, among the dicot weeds and *cyperus rotundus, cynodon dactylon, dinebra arabica, panicum spp. Cynodon dactylon, digitaria sanguinalis, amaranthis viridis, Cyperus rotundus, Erogrostis* major were the major monocot weeds.
Poonia *et al.* (2013) [27] at Gujarat they noticed the dominant weed flora of experimental field were *Cyperus rotondus, Eluropus, Eleusine indica* among moncot. Among dicot, *Chenopodium album, Melilotus indica, Euphorbia hirta* and Diger arvensis were found dominant weed.
Khan *et al.* (2011) Peshawar, Pakistan reported that most problematic weeds in chickpea crop and highest Weeds Germination in mid-February due to rainfall. The weed i.e. *poa annum* L., *Anagallis arvensis* L., *Ammi visanga* (L.) *Lam*. and *Euphoria helioscopia* L. were present in field.

Critical period of weed interference
There are lots of crops that are able to tolerate the interfering caused by weeds to definite period of time Mohammadi *et al.* (2005) [23] reported that a CPWC 17 to 49 days after emergence (DAE) or between the four leaf and establishment of flowering in chickpea crop. Singh *et al.* (2004) reported that under irrigated condition simultaneous emergence and rapid growth of weed along with chickpea crop in the field caused severe weed- crop competition in early stages. Mukherjee (2007) [24] at Kampong in West Bengal reported that in rabbi season weeds emergence fast as compare to crop and making competition with crop at 16-48 DAS.
(Yenish, 2007) [41]. Reported that the average critical period of crop weed competition is 23 to 52 DAE, but the approximations for the lower and upper limit reached from 0 to 35 and 42 to 60 DAE. Sharma *et al*. (2007) [30, 31] and Kumar and Singh (2010) [16] reported that 30 to 60 DAS was the critical period of weed competition because of slow growth in chickpea. Ratnam *et al*. (2011) [29] reported that critical period of crop weed competition is 8 weeks of chickpea. Smitchger (2010) [37] find that the Critical Period of WC for the 'Sierra' chickpea was 16 to 26 DAE. Patel *et al.* (2006) [25, 26] reported that weeds reduce growth of crop at early stage and reduce soil fertility, available soil moisture, and nutrients and also compete for space and sunlight, therefore cause considerable yield loss up to 88 per cent in chickpea.

Losses caused due to weeds
Weed is serious problem in field crop when they not controlled by early growth stages then they may be failure of crop maximum losses in crop yield Poonia (2013) [27] recorded that weedy situation prevailing throughout the crop period caused 54.7% reduction in yield of chickpea respectively.
Bulti Merga (2019) [21] they reported that the crop yield loss caused by the weed is assumed greater than 20%, in Ethiopia
Gore *et al*., (2013) At Parbhani, Maharashtra reported that in *rabbi* season weed infested on crop and resulting yield loss of 40 to 87% of chickpea crop.
Khope *et al*. (2011) [19] reported that the weeds in chickpea caused 68.2% reduction in grain yield. Kumar and Singh (2010) [16] reported that loss in grain yield of chickpea due to weed infestation may range from 29 to 70 per cent.
Sharma *et al*. (2007) [30, 31] found that the loss of chickpea yield may go up to 50 to 70 per cent, depending upon the type of weed flora present and their intensity in an area. Kacchhadia *et al*. (2005) reported that the weed causes 31.33% yield losses in chickpea crop.
Patel *et al.* (2006) [25, 26] reported that weeds effect growth, yield and quality of crop plants and reduce soil fertility, available
soil moisture, nutrients and also compete for space and sunlight, therefore cause considerable yield loss up to 88 per cent in chickpea.

Weed management practices
The gentle growth habit of chickpea causes the crop is severely infested by the weeds in the dry land as well as irrigated areas.

Chemical weed control
Chaudhary *et al*. (2005) [6] noted the higher number of pods/plant (34.59), seeds/pod (1.62) of chickpea with hand weeding twice at 20 and 40 DAS followed by pre-emergence application of pendimethalin @ 1.0 kg/ha (33.68 and 1.5, respectively).
Kaur *et al*. (2010) [13] reported that the higher dose of pendimethalin (0.75 kg/ha) was more effective in controlling weeds than the lower dose (0.45 kg/ha) and the highest grain yield 15.10 q/ha was obtained in two hand hoeing's at 25 and 40 DAS followed by pendimethalin 0.75 kg/ha.
Kakde *et al*., (2020) [38] at Akola reported that maximum B: C ratio was found with application of oxyflourfen @ 150 g /ha (3.00) which was closely followed by Imazethapyr 10% @ 50 g/ha (2.87).
Gore *et al*. (2018) [10] at Parbhani reported that the application of pre-emergence herbicide pendimethalin @ 0.75 kg/ha were highest grain yield (2476 and 2376 kg/ha) during first year and second year yield is (2261 and 2167 kg/ha).
Kour *et al.* (2014) reported that the pre-emergence application of pendimethalin @ 1 kg/ha gave the maximum weed-control efficiency (85.16%), net returns (20,373/ha) and benefit: cost ratio (1.71) in chickpea+ mustard intercropping system.
Kaushik *et al*. (2014) reported that the application of pre-emergence herbicide of pendimethalin at 0.75 kg/ha + one hand weeding at 25 DAS in maximum net return (RS 39,726/ha).
Poonia (2013) [27] reported that the maximum herbicidal efficiency index was achieved under pendimethalin 38.7% CS @ 1.0 kg/ha as PE + hoeing at 30-35 DAS 100.9% followed by pendimethalin 30% EC @ 1.0 kg/ha as PE + HW at 25-30 DAS 96.5% and oxyfluorfen 23.5% EC @ 0.25 kg/ha as PE at 20 DAS + hoeing at 30-35 DAS.
Kumar and Nanda (2014) [20] reported that the pre-emergence

application of pendimethalin @ 1 kg/ha as effectively controlled *Chenopodium album*, *Medicago denticulate* and *phalaris minor*.

Khairnar *et al*. (2014) [18] reported that the application of imazethapyr @ 1 kg/ha and 0.075 kg/ha at 20 DAS followed two hand weeding result effective control broad leaf weeds like *Commmelina diffusa*, *Amaranthus viridis*, grassy weeds like *Bracharia spp*., *Echinochloa colona*, perennial sedges like *Cyprus rotundas*, recorded highest total dry matter production (25.18 g m^{-2}) at 30 DAS record weedy check plot low total biomass was recorded with (1.34 g m^{-2}) two hand weeding.

Chandrakar and Sharma (2015) reported that the application of pendimethalin 20.75 kg/ha with one hand weeding at 45 DAS resulting lowest dry weight of weed (10.14 kg/ha).

Rathod *et al*. (2016) [28] reported that the application of pre-emergence of pendimethalin 38% CS 0.75 kg/ha + HW at 30 to 35 DAS recorded the lowest weed dry weight (11.3 g m^{-2}).

Muhammad *et al*. (2011) [22] reported that the weed index (WI) was the highest (50.1%) in untreated plots while the lowest 7.34-10.35% in Stomp 330E @ 3.00 lit ha^{-1} and 35.59-38.0% in Puma Super 75EW @ 1.25 liter/ha.

Cultural method

Aslam *et al*. (2007) [7] reported that the hand weeding gave maximum number of pods/plant (41.26 and 46.71) followed by pre-emergence application of Ppendimethalin as 32.32 and 41.83 pods/plant during the first and second year of experiment, respectively.

Hassan and Khan (2007) [11] reported that the highest number of pods/plant was recorded in hand weeding (45). It was however, statistically similar with Post-emergence application of metribuzin @ 2.45 kg/ha plots (44. 60) and weedy check (36.60).

Sharma (2009) [32] from Rajasthan revealed that the two hand weeding at 20 and 40 DAS recorded lowest dry weight of both monocot and dicot weeds and higher weed control efficiency 61.5 per cent in chickpea but among the herbicide treatments.

Bhooshan and Singh (2014) [2] revealed that one hand weeding at 25 DAS produced significantly higher grain yield/plant as compared to pendimethalin 1.0 kg ha^{-1} applied as pre-emergence and weedy check.

Dewangan *et al*. (2016) [28] reported that the yield attributes seed yield, Stover yield were recorded under two hand weeding at 25 and 45 DAS. Use pre-emergence herbicide oxyfluorfen + metribuzin at 125 + 350 g/ha and yield increases 74.36 and 73.1% respectively.

Rathod *et al*. (2016) [28] reported that two HW at 20 and 40 DAS resulted higher seed yield (1244 kg/ ha), application of pre-emergence herbicide pendimethalin @ 38 CS 0.75 kg/ha + HW at 30 to 35 DAS optimum seed yield of chickpea under rain fed conditions of Karnataka.

Chavada and Patel (2017) reported that the HW + IC at 30 and 45 DAS that result to highest seed yield (2562 kg/ha).

Kakade *at el.,* (2020) [38] reported that the maximum GMR of Rs. 93120 ha-1 and NMR of Rs.59679/ha was recorded in HW twice at 30 and 50 DAS, followed by treatment of oxyflourfen @ 150 g/ha.

Effect of weed management practices on weed characteristics and weed control efficiency

Weed density

Aslam *et al*. (2007) [7] recorded that the hand weeding gave minimum weed density with 79% weed control and minimum values for dry weed biomass during both the years of trial. Thus hand weeding decreased 98% dry weed biomass against weedy check.

Singh *et al*. (2008) [35] from Ludhiana reported that pre-emergence application of pendimethalin @ 0.5 kg/ha or trifluralin @ 0.5 kg/ha as PPI each integrated with one hand weeding 45 DAS decreased dry matter accumulation by weeds to the tune of 86 and 82% as compared to unwedded control and both these integrated treatments increased seed yield of chickpea by 60 and 59% than control.

Bhooshan and Singh (2014) [2] revealed that the significantly lower weed density and dry matter was recorded in hand weeding at 25 DAS treatment than the pre-emergence application of pendimethalin 1.0 kg/ha.

Singh *et al*. (2014) at Hisar reported that the pre-emergence application of pendimethalin herbicide @ 1.5 kg/ha gave effective control against all the weeds whereas, among post emergence herbicides imazethapyr was found effective against broadleaf weeds and quizalofop-ethyl was effective only against grassy weeds in mungbean.

Kumar and Nanda (2014) [20] reported that the pre-emergence application of pendimethalin @ 1 kg/ha as effectively controlled *Chenopodium album*, *Medicago denticulate* and *phalaris minor*.

Dewangan *et al*. (2016) [8] reported that the dominant weed flora of experimental field consist of *Medicago denticulate* (41.9%), *Convulvulas arvensis* (23.7%), *Chenopodium album* (5.1%), *Melilotus indica* (5%), *Brachiaria mutica* (12.7%), and other weeds (11.6%).

Singh *et al*. (2017) reported that among the monocot weeds are *Cyperus rotundus* (33.1%), *Cynodon dactylon* (27.8%), among the dicot weeds are *Launea pinnatifolia* (13.3%), *Chenopodium album* (6%) and *Anadallis arvensis* (4.8%).

Bulti Merga (2019) [21] recorded that total minimum weed density (21.78 g/m) S-metolachlor 1.0 kg/ha + HW at 5 WAE.

Kakde *at el*, (2020) [38] at Akola they reported that two HW at 30 and 50 DAS recorded lowest weed density (4.79%) at harvest as compare to chemical treatments.

Weed dry weight

Dhuppar *et al*. (2013) [9] reported that among all the weed management treatments, hand weeding gave the highest weed control (84.8%) and produced lower weed biomass (54.0 g m^{-2}) in lentil crop.

Bhooshan and Singh (2014) [2] revealed that the lower weed density and dry matter was recorded in HW at 25 DAS treatment than the pre-emergence application of pendimethalin 1.0 kg/ha. Chandrakar and Sharma (2015) reported that the application of pendimethalin 20.75 kg/ha with one hand weeding at 45 DAS resulting lowest dry weight of weed (10.14 kg/ha).

Rathod *et al*. (2016) [28] reported that the application of pre-emergence pendimethalin 38% CS 0.75 kg/ha + HW at 30 to 35 DAS recorded the lowest weed dry weight (11.3 g m^{-2}).

Dewangan *et al*. (2016) [8] reported that the two HW at 25 and 45 DAS reducing weed density (1.28 no.m^{-2}) and weed dry weight (0.60 g m^{-2}) herbicide combination of oxyfluorfen + metribuzin at 125 +350 g/ha as pre-emergence were most effective in reducing weeds density (7.25 no. m^{-2}) and weeds dry weight (4.72 g m^{-2}). Singh *et al*. (2017) [36] reported that the application of pendimethalin 1 kg/ha + hand weeding 30 DAS result low weed dry weight (3.25 g m^{-2}).

Gore *et al*. (2018) [10] reported that the application of pre-

emergence of herbicide of pendimethalin @ 0.75 kg/ha observe dry weight of monocot and dicot weeds are (3.07 g m^{-2}) and (5.32 g m^{-2}) at 30 DAS.
Kakade *at el*, (2020) [38] at Akola they reported that two HW at 30 and 50 DAS recorded lowest weed dry matter (3.39 g/m) at harvest as compare to chemical treatments.

Weed control efficiency
Tewari and Tiwari (2004) reported that the higher weed control efficiency was recorded with pre-emergence application of pendimethalin @ 1.0 kg/ha and oxadiazon @ 1.25 kg/ha in chickpea.
Sharma (2009) [32] from Rajasthan revealed that the two HW at 20 and 40 DAS recorded lowest dry weight of both monocot and dicot weeds and higher weed control efficiency 61.5 per cent in chickpea but among the herbicides respectively.
Muhammad *et al*. (2011) [22] reported that the weed index (WI) was the highest (50.1%) in untreated plots while the lowest 7.34-10.35% in Stomp 330E @ 3.00 lit/ha and 35.59-38.0% in Puma Super 75EW @ 1.25 liter/ha.
Kour *et al*. (2014) [14] reported that the pre-emergence application of pendimethalin @ 1 kg/ha gave the maximum weed-control efficiency (85.16%), net returns (20,373/ha) and benefit: cost ratio (1.71) in chickpea+ mustard intercropping system.
Rathod *et al*. (2016) [28] reported that the application pre-emergence herbicide of pendimethalin 38% CS 0.75 kg/ha + HW at 30 to 35 DAS recorded the highest weed control efficiency (83.06%).
Ruparelia *et al*. (2017) reported that the HW at 25 DAS and resulted highest weed control efficiency (100%), oxyfluorfen 0.18 kg/ha as pre-emergence followed by pre-mix (imazamox + imazethaypr) @ 0.03 kg/ha (92.9%) respectively.
Gore *et al*. (2018) [10] recorded that the weed free plot of weed control efficiency of monocot and dicot weeds is (78.5%) and (82.87%). propaquizofop at 0.75 kg/ha of weed control efficiency monocot weeds are (73.42%) and dicot weeds are (73.98%).
Kakade *at el.*, (2020) [38] reported that the maximum weed control efficiency (84.31%) and minimum weed index (5.07%) was observed in oxyflourfen @ 150 g /ha PoE 40 DAS and higher weed index observed in weedy check (45.90%).

Current and future prospects
I am doing now doctoral research on different pre and post emergence herbicides on weed control and growth and yield of spring maize. In respects to agriculture, weeds are quiet and serious problem to crop production. Agricultural practices have advanced over time and scientific community resolved that single method is not sufficient to control the weed infestation and all integrated approach is the future of weed control. During the latest years, the idea of precision agriculture has
vastly enlarged and it has not yet ceased. The usage of herbicides when essential is being stressed in order to decrease the carry over effects of herbicide. Considering this in view, the habit of post-emergence herbicides is being supported. The influence of additional agricultural practices like irrigation and nutrient management on the weed emergence has not been discussed due to inadequate research. This may be attributed to the fact that pulses are generally grown in the semi-arid (dry land areas) of the nation. Genetically improved crops, like soybean, with resistance to broad-spectrum post-emergence herbicides such as glyphosate, have been established through genetic engineering. Related tendencies can also be the future of Chickpea and other pulse crops where mechanization is a severe limitation to the production.

Conclusion
Weeds are the very severe problem, and can cause 20-90 per cent yield reduce in various pulse crops (Pooniya *et al.*, 2013). Weed make competition with the crops for requirements like light, water, space, nutrition etc. thereby dropping the crop yield. Pulses are exactly diverse agricultural share and intensely compressed by weed stress. Hence, there is horrible need to shift to newer herbicide application for superior weed control. However, with the recent idea of precision farming, the practice of post-emergence herbicide is being supported. Any single herbicide not able to control all types of weeds. In the current setting, actions have been made to comprise the different pre and post-emergence herbicides with cultural method is useful for success weed management.

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