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To study the effect of different herbicides on density and dry matter production of weeds

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Abstract
The present investigation entitled "Bioefficacy of broad spectrum herbicides for weed management in chickpea (*Cicer arietinum* L.)" was carried out at the Instructional cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) during *rabi* season 2017-18. The soil of experimental field was clayey (*Vertisols*) in texture, locally known as "*Kanhar*" which was low, medium and high in available N, P_2O_5 and K_2O, respectively. The experiment was laid out in Randomized Block Design with three replications. The treatment consisted of Pendimethalin 30 EC @ 1.0 kg ha^{-1} PE + One hand weeding at 30 DAS (T_1), Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE (T_2), Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_3), Sulfentrazone 39.6 EC @ 50g ha^{-1} PE + one hoeing at 30 DAS (T_4), Fenoxaprop-p-ethyl 9.3 EC @ 60g ha^{-1} POE at 25 DAS (T_5), Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE (T_6), Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_7), Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + Imazethapyr 2% (tank mix) @ 1.0 kg ha^{-1} (T_8), Hand weeding at 30 DAS (T_9), Weed free (hand weeding at 20 and 40 DAS) (T_{10}), Weedy check (T_{11}). The chickpea variety Vaibhav was grown as test crop on November 15, 2017 and harvesting was done on March 07, 2018.

Keywords: bioefficacy, weed management, chickpea (*Cicer arietinum* L.)

Introduction
Chickpea (*Cicer arietinum* L.) is the most important winter season pulse crop. It is a source of protein and it plays an important role in human nutrition for large population in the developing world. Chickpea valued for its nutritive seeds with high protein content 18-22%, carbohydrate 52-70%, fat 4-10%, minerals (Calcium, Phosphorus and Iron) and Vitamins. Chickpea is the second most important pulse crop after pigeon pea in the world for human diet and other use. It is cultivated in area of 139.81 *lakh ha* with a total production of 137.31 *lakh tones* and average productivity of 982 kg ha^{-1} (FAO, 2017) [3]. Chickpea also plays a main role in increasing soil fertility due to its nitrogen fixing ability. Chickpea can fix up to 140 kg N ha^{-1} in a growing period (Poonia and Pithia, 2013) [9]. It leaves substantial amount of residual nitrogen for subsequent crops and adds plenty of organic matter to maintain and improved soil health and fertility.

In chickpea production, one of the major constraints is weed infestation. Weeds compete with crop plants for space, water and nutrients and hence, it causes considerable yield losses. Thus, weeds are one of the major constraints to obtain high grain yield of improved crop cultivars if they are not controlled timely and properly. Chickpea is poor competitor to weeds because of slow growth rate and limited leaf development at early stage of crop growth and establishment, if weed management is neglected under these conditions, resulting in yield loss of 40 to 87% (Ratnam *et al*., 2011). Weeds emerge with the winter sown crop and create severe competition unless controlled timely and effectively. Yield losses due to weed competition vary considerably depending on the level of weed infestation and weed species prevailing.

The important weeds found in weed of chickpea includes *Chenopodium album, Medicago denticulata, Echinochloa colona, Parthenium hysterophorus, Cynodon dactylon*, Hand weeding and mechanical weed control methods traditionally followed in the developing countries are becoming expensive due to increased labor wages. Because of the sensitivity of chickpea to herbicides, most effective are the pre-emergence herbicides, and choices for post-emergence herbicides are limited. The pre-emergence herbicides are effective in controlling weeds at early stage of seedling growth, but weeds germinating after crop emergence become dominant in the field and cause substantial yield loses. Therefore, chickpea cultivars with improved herbicide tolerance, which can offer greater flexibility for use of post-emergence herbicides, are required by the farmers. Weed management through herbicides is needed even in the developing countries, such as India, to make chickpea cultivation more profitable. Weed management through herbicides is not only economical but also facilitates zero-tillage or minimum tillage methods, which help in practicing conservation agriculture. Chemical control of weeds also involves various options; pre-planting treatment is applied before crop is sown, where the herbicides used are acting on germinating seedlings. Pre emergence treatments are applied after seeding but before the crop emerges, chemicals may control weeds by killing weed seedlings. While, post-emergence herbicides are applied after the emergence of crop plants and weeds, with selective herbicides weeds are killed with little damage to crop plants due to differential tolerance of the crop and weed to the herbicides. Chickpea is known to be sensitive to many herbicides and, therefore, choices for using post-emergence herbicides for weed control are limited.

Materials and Methods
The present investigation entitled "Bioefficacy of broad spectrum herbicides for weed management in chickpea

(*Cicer arietinum* L.)"was carried out during *rabi* season of 2017-18 (November to March) at Instructional Cum Research Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh, with the objective to find out suitable weed management practices for chickpea under the agro-climatic condition of Chhattisgarh plain. The soil of the experimental field was clayey (Vertisols) nature with low, medium and high in N, P and K, respectively. The climate of the region is sub humid to semiarid. Experiment was laid out in Randomized Block Design with three replications. The treatments comprised of eleven weed management practices viz, Pendimethalin 30 EC @ 1.0 kg ha^{-1} PE + One hand weeding at 30 DAS (T_1), Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE (T_2), Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_3), Sulfentrazone 39.6 EC @ 50g ha^{-1} PE + one hoeing at 30 DAS (T_4), Fenoxaprop -p-ethyl 9.3 EC @ 60g ha^{-1} POE at 25 DAS (T_5), Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE (T_6), Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_7), Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + Imazethapyr 2% (tank mix) @1.0 kg ha^{-1} (T_8), Hand weeding at 30 DAS (T_9), Weed free (hand weeding at 20 and 40 DAS) (T_{10}) and weedy check (T_{11}). The chickpea variety vaibhav was sown as test crop on November 15, 2017 with a seed rate of 80 kg ha^{-1}. The crop was harvested on March 07, 2018.

Results and Discussion

Total weed density (No. m^{-2})

Total weed density of *Medicago denticulata, Echinochloa colonum, Chenopodium album, Parthenium hysterophorus, Cynodon dactylon* and others were recorded at 30, 60, 90 DAS and at harvest and data are presented in Table 1. The total weed density was significantly influenced by different weed management treatments during all the stages of observations. At 30 DAS, minimum total weed density was observed under the treatment of weed free (hand weeding at 20 and 40 DAS), however, it was at par to the treatment of Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_7). Similarly, at later time interval of observations *i.e.* at 60, 90 DAS and at harvest, significantly lowest total weed density was recorded under the hand weeding twice at 20 and 40 DAS (T_{10}), which was significantly superior over other treatments, while, it was higher under weedy check (T_{11}) as compared to rest of the treatments. These results were in accordance to the findings of Hassan and Khan (2007) [4], Singh *et al.* (2011) [12].

Among the herbicidal treatments, significantly lower weed density recorded under the treatment of Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_7), which was at par with Sulfentrazone 39.6 EC @ 50g ha^{-1} PE + one hoeing at 30 DAS (T_4) and Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_3), respectively, and significantly superior rest of the treatments. Thus, on the basis of above results, it can be stated that the trend of weed density was in ascending order from 30 DAS to harvesting stage. Use of herbicides and hand weeding drastically reduced the weed density at the early stage of crop growth. In general, infestation of weeds increased with time under control plot (T_{11}) up to harvest and maximum weed density was observed in control plot (T_{11}) throughout the crop growth period because no control measure was adopted.

Table 1: Total weed population in chickpea as influenced by different weed control measures

Treatment	Weed population (No.m^2)			
	30 DAS	60 DAS	90 DAS	At harvest
T_1 - Pendimethalin 30 EC @ 1.0 kg ha^{-1} PE + One hand weeding at 30 DAS	6.06 (36.26)	5.72 (32.25)	4.95 (24.05)	4.75 (22.09)
T_2 - Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE	5.97 (35.16)	6.97 (48.02)	6.19 (37.78)	6.00 (35.51)
T_3 - Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + one hoeing at 30 DAS	5.99 (35.40)	5.56 (30.41)	4.94 (23.87)	4.49 (19.64)
T_4 - Sulfentrazone 39.6 EC @ 50g ha^{-1} PE + one hoeing at 30 DAS	5.74 (31.28)	5.16 (25.58)	4.51 (19.39)	3.96 (15.02)
T_5 - Fenoxaprop -p-ethyl 9.3 EC @ 60g ha^{-1} POE at 25 DAS	8.93 (79.31)	7.60 (57.24)	6.40 (40.45)	5.24 (26.95)
T_6 - Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE	5.62 (31.11)	6.31 (39.34)	5.49 (29.64)	5.29 (27.51)
T_7 - Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE + one hoeing at 30 DAS	5.59 (30.78)	4.55 (20.13)	4.02 (15.65)	3.59 (12.38)
T_8 - Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + Imazethapyr 2% (tank mix) @ 1.0 kg ha^{-1}	5.97 (35.16)	6.33 (39.58)	5.70 (31.95)	5.23 (26.87)
T_9 - Hand weeding at 30 DAS	9.01 (80.77)	7.00 (48.51)	6.50 (41.75)	6.09 (36.60)
T_{10} - Weed free (hand weeding at 20 and 40 DAS)	4.74 (22.41)	3.76 (13.67)	3.52 (11.92)	3.13 (9.31)
T_{11} - Weedy check	10.23 (103.72)	10.83 (116.79)	9.92 (97.82)	9.44 (88.68)
SEm±	0.22	0.20	0.18	0.16
CD (P=0.05)	0.65	0.60	0.54	0.49

Total weeds dry matter production (g m^{-2})

The total weed dry matter was significantly influenced by different weed management treatments at 30, 60, 90 DAS and at harvest and data are presented in Table 2. Significantly higher total dry matter of weed species namely *Medicago denticulata, Chenopodium album Cynodon dactylon, Parthenium hysterophorus Echinochloa colona* and others were observed under weedy check (T_{11}) as compared to rest of the treatments.

At 30 DAS, significantly lower total dry matter of weed species was observed under the treatment of weed free (hand weeding at 20 and 40 DAS) (T_{10}), however, it was at par to the treatment of Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_3) and Pendimethalin 30 EC @ 1.0 kg ha^{-1} PE + One hand weeding at 30 DAS (T_1) as compared to weedy check (T_{11}) and rest of the treatments. At later time interval of observations *i.e.* at 60, 90 DAS and at harvest, weed free (hand weeding at 20 and 40 DAS) (T_{10}) resulted in significant reduction in total dry matter production of weeds which, was significantly superior over

other treatments. The results were in agreement with the findings of Patel *et al.* (2006) [8], Kumar *et al.* (2008) [7], Singh *et al*. (2008) [11], Sadiq *et al*. (2011) [10]. However, among the herbicidal weed management treatments, significantly lower total weed dry matter was recorded under Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_7) and Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + one hoeing at 30 DAS (T_3), which were at par to each other at all the later stages of observation i.e. 60, 90 DAS and at harvest, and were significantly superior over rest of the treatments. While highest dry matter production was noted under weedy check (T_{11}). Similar results were observed by Aslam *et al.* (2007) [4], Butter *et al.* (2008) [5], Chaudhary *et al.* (2011) [6], Sadiq *et al.* (2011) [10], Poonia and Pithia (2013) [9], who reported that the highest weed density and dry weight of weeds was recorded in weedy check.

Table 2: Weeds dry weight of chickpea as influenced by different weed control measures

Treatment	Weeds dry weight (gm^2)			
	30 DAS	**60 DAS**	**90 DAS**	**At harvest**
T_1 - Pendimethalin 30 EC @ 1.0 kg ha^{-1} PE + One hand weeding at 30 DAS	3.95 (14.90)	3.81 (13.78)	4.42 (19.02)	4.64 (21.04)
T_2 - Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE	3.98 (15.31)	4.23 (17.43)	4.48 (19.65)	4.71 (21.73)
T_3 - Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + one hoeing at 30 DAS	3.79 (14.12)	3.54 (12.05)	4.17 (16.84)	4.78 (19.52)
T_4 - Sulfentrazone 39.6 EC @ 50g ha^{-1} PE + one hoeing at 30 DAS	3.95 (15.09)	3.83 (14.17)	4.32 (18.01)	4.80 (22.47)
T_5 - Fenoxaprop -p-ethyl 9.3 EC @ 60g ha^{-1} POE at 25 DAS	5.55 (30.31)	5.33 (27.87)	5.64 (31.30)	5.23 (23.13)
T_6 - Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE	4.27 (17.21)	4.38 (18.66)	4.74 (21.99)	4.98 (24.23)
T_7 - Pendimethalin 30 EC + Imazethapyr 2 % (Ready mix) @1.0 kg ha^{-1} PE + one hoeing at 30 DAS	3.45 (11.90)	3.26 (10.13)	3.87 (14.43)	4.07 (15.39)
T_8 - Pendimethalin 38.7 CS @ 1.0 kg ha^{-1} PE + Imazethapyr 2% (tank mix) @ 1.0 kg ha^{-1}	4.07 (16.11)	4.29 (17.88)	4.82 (22.73)	5.05 (24.68)
T_9 - Hand weeding at 30 DAS	5.54 (30.16)	5.18 (26.30)	5.81 (33.21)	5.96 (34.99)
T_{10} - Weed free (hand weeding at 20 and 40 DAS)	2.97 (8.30)	2.90 (7.89)	2.98 (8.47)	3.15 (9.44)
T_{11} - Weedy check	6.61 (43.19)	7.43 (54.67)	7.61 (55.28)	7.69 (50.71)
SEm±	0.14	0.14	0.15	0.16
CD (P=0.05)	0.42	0.42	0.46	0.49

Figures in parenthesis indicated the original value, data transformed to ($\sqrt{x}+0.5$)

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