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Studies on herbicide residual effect on yield parameters of cotton (*Gossypium hirsutum* L.) - chickpea (*Cicer arietinum* L.) cropping sequence

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Abstract
A field investigation was undertaken at cotton research scheme farm, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S) during 2018-19 and 2019-20 under irrigated condition (drip) to study the herbicide residue effect on yield parameters in succeeding chickpea crop. The experiment was laid out in a randomized block design with seven treatments in three replications. Chickpea was sown on the same field after harvesting of cotton without disturbing the design without practicing any weed control methods. Significant residual effect of different herbicides were observed on yield parameters of succeeding crop. The yield attributes *viz*., pods plant^{-1}, seed pod^{-1} and grain pod^{-1} were differentially influenced by residual effect of weed management during both the years of study. The pooled results revealed that POE pyrithiobac sodium @ 62.5 g ai/ha + quizalofop ethyl @ 50 g ai/ha at 30 DAS followed by one hand weeding at 60 DAS recorded the highest grain yield (1912 kg ha^{-1}), biological yield (4479 kg ha^{-1}) and harvest index (42.68%).

Keywords: Residual effect, yield parameters, chickpea, grain yield, pods plant^{-1}, biological yield and harvest index

Introduction
Chickpea (*Cicer arietinum* L.) is the third largest produced food legumes globally cultivated in more than 50 countries across Asia, Africa, Europe, North America and South America. It is a good and cheap source of protein for people in developing countries, who are vegetarians. It is an ancient self-pollinated legume crop and also used to rehabilitate depleted fallow lands through utilizing crop rotation system. Chickpea is poor competitor to weeds because of slow growth rate and limited leaf development. The flowering stage is most sensitive to cold stress and determines the yield of chickpea (Sharma and Nayyar, 2014) [5]. It plays an important role in improving soil fertility by fixing atmospheric nitrogen. Temperature below 15 C during flowering leads to decline in the number of pods plant^{-1} and seeds pod^{-1} (Clarke and Siddique, 2004; Kaur *et al.*; 2011; Kumar *et al.*; 2017).

Materials and Methods
A field experiment entitled "Effect of weed control methods on productivity of Bt cotton (*Gossypium hirsutum* L.) – chickpea (*Cicer arietinum* L.) cropping sequence" was conducted during 2018-19 and 2019-20 at experimental farm of Cotton Research Scheme, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.). The soil of experimental plot was low in available nitrogen (198.6 and 202.4 kg ha^{-1}), low in phosphorus (17.52 and 18.32 kg ha^{-1}), high in available potassium (588.50 and 596.18 kg ha^{-1}) and alkaline (pH 8.14 and 8.16) in reaction during 2018-19 and 2019-20, respectively. The soil was clayey in texture with moderate moisture holding capacity which was good for normal growth of the crop. The experiment was laid out in a randomized block design with seven treatments in three replications. The treatments comprised: T_1–PE pendimethalin @ 0.75 kg a.i. ha^{-1} *fb* one hand weeding at 60 DAS, T_2–PE pyrithiobac sodium @ 62.5g a.i. ha^{-1} *fb* one hand weeding at 60 DAS, T_3–PE pyrithiobac sodium @ 62.5g a.i. ha^{-1} *fb* quizalofop ethyl @50 g a.i. ha^{-1} at 60 DAS, T_4–POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS *fb* one hand weeding at 60 DAS, T_5–POE paraquat dichloride (directed spray) 24% SL @ 0.5 kg a.i. ha^{-1} at 30 DAS *fb* one hand weeding at 60 DAS, T_6–Weed free, T_7–Weedy check. Parbhani is located at 19.27^0 North Latitude and 76.78^0 East Longitude and has an average elevation of 347m from sea level.

It comes under semi-arid region receiving maximum rainfall from south west monsoon and climate is tropical. The maximum temperature was 41.1 ^{0}C and 40.9 ^{0}C whereas lowest minimum temperature was 7.9 ^{0}C and 12.3 ^{0}C during 2018-19 and in 2019-20, respectively. The morning and evening mean relative humidity was 71 to 92 percent in 2018-19 and 94 to 66 percent in 2019-20, respectively. The total rainfall during the experimental period was 781.4 mm which was spread over 26 rainy days in 2018-19 and 1029.1 mm which was spread over 62 rainy days in 2019-20. The distribution of rainfall was normal for growth of cotton crop. In general, the climatic conditions were favourable for the cotton growth. Due to sufficient moisture in soil received through rainfall at seedling stage the growth was satisfactory. There was even distribution of rainfall during the crop growth, protective irrigations at critical growth stages of crop were given. The yield level of cotton crop was good. The evaporation ranges between 2.4 to 11.4 mm day^{-1} in 2018-19 and 2.1 to 10.4 mm day^{-1} in 2019-20. Chickpea was sown on 1st Dec 2019 during 48th week meteorological week. The fertilizers were applied as recommended dose *i.e.,* 25:50:00 (N: P: K) kg ha^{-1}. As chickpea is a leguminous crop, full dose of fertilizer was applied as basal dose. Three irrigation at pre-sowing, flowering and pod development stage were given. Chickpea crop was harvested on 28.3.2019 and 27.3.2020 when plants started drying to pale colour, leaves started shedding and pods turned yellowish dark brown and dried. The harvested produce was sundried for 2 to 3 days and then it was threshed treatment wise separately. The plants from each net plot were harvested and seeds were separated from pods by threshing. After sun drying, seed yield obtained in each net plot was weighed in kg and converted into seed yield kg ha^{-1}. The harvest index was calculated by dividing seed yield hectare^{-1} by total biological yield and expressed in percentage.

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

Results and Discussion

Pods plant^{-1}

At harvest, the chickpea pods plant^{-1} were significantly influenced by residual effect of weed management practices, as presented in Table 1. In 2018-19, maximum number of pods plant^{-1} (46.3) was recorded with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS which was at par with weed free treatment and significantly higher as compared to all other weed management practices. In 2019-20, treatment weed free recorded maximum number of pods plant^{-1} which was at par with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS and significantly higher as compared to all other weed management practices. This might be due to low competition of weeds (low weeds density) which led to more nutrient absorption from the soil that positively influenced the yield parameters. These are results are corroborating with the results of Singh and Jain, (2017) [9], Kaushik *et al.* (2014), Singh *et al.* (2008) [8] and Dubey *et al.* (2018).

Number of seed pod^{-1}

At harvest, the chickpea seed pod^{-1} was not significantly influenced by residual effect of weed management practices during 2018-19 and 2019-20, as presented in Table 1.

Seed weight plant^{-1}

The chickpea seed weight plant^{-1} (g) was significantly influenced by residual effect of weed management practices, as presented in Table 1. Maximum seed weight plant^{-1} of 11.9 g in 2018-19 was recorded with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS which was at par with weed free treatment whereas in 2019-20, weed free recorded the maximum seed weight plant^{-1} of 12.10 g which was at par with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS and significantly higher as compared to all other weed management practices in 2018-19 and 2019-20, respectively.

Table 1: Residual effect of weed management practices on pods plant^{-1}, seeds pod^{-1} and seed weight plant^{-1} of chickpea during 2018-19 and 2019-20

Treatment	Pods plant^{-1}		Seeds pod^{-1}		Seed weight plant^{-1}	
	2018-19	2019-20	2018-19	2019-20	2018-19	2019-20
T_1	41.6	44.1	1.57	1.66	10.0	10.30
T_2	41.0	43.9	1.59	1.61	9.60	9.90
T_3	38.6	40.1	1.58	1.43	9.10	9.40
T_4	46.3	47.9	1.63	1.73	11.90	11.40
T_5	39.7	41.6	1.43	1.54	9.20	9.60
T_6	45.6	48.1	1.60	1.83	10.80	12.10
T_7	38.1	39.5	1.77	1.37	8.90	9.1
S.E. (m) +	1.38	0.86	0.04	0.06	0.40	0.24
C.D. at 5%	4.26	2.66	NS	NS	1.25	0.74
General mean	41.3	43.36	1.59	1.60	9.90	10.25

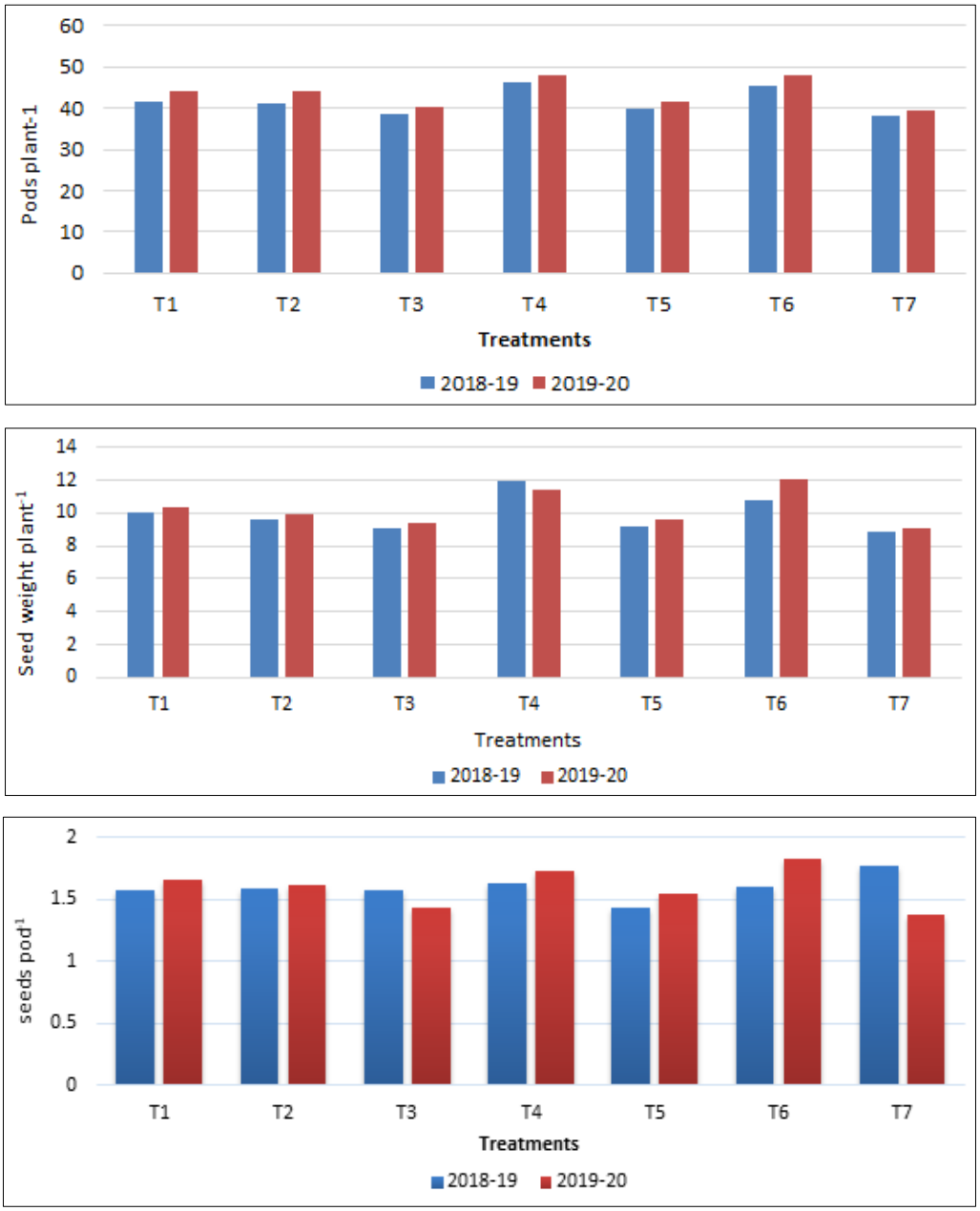

Fig 1: Residual effect of weed management practices on pods plant^{-1}, seeds pod^{-1} and seed weight plant^{-1} of chickpea during 2018-19 and 2019-20

Grain yield

The data pertaining to chickpea grain yield (kg ha^{-1}) is depicted in Table 2. Chickpea grain yield (kg ha^{-1}) was significantly influenced by residual effect of weed management practices. Maximum grain yield (kg ha^{-1}) of 1896 in 2018-19 was attained with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS which was at par with weed free treatment (1843 kg ha^{-1}), PE pendimethalin @ 0.75 kg a.i. ha^{-1} followed by one hand weeding at 60 DAS (1735 kg ha^{-1}) and PE pyrithiobac sodium @ 62.5 g a.i. ha^{-1} followed by one hand weeding at 60 DAS (1679 kg ha^{-1}) and significantly higher as compared to all other weed management practices. The lowest grain yield (1188 kg ha^{-1}) was obtained with weedy check treatment. In 2019-20, maximum grain yield (1976 kg ha^{-1}) was attained with weed free treatment and was at par with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS (1927 kg ha^{-1}) and PE pendimethalin @ 0.75 kg a.i. ha^{-1} followed by one hand weeding at 60 DAS (1782 kg ha^{-1}) and significantly higher as compared to all other weed management practices. The lowest grain yield (1217 kg ha^{-1}) was obtained with weedy check treatment. In pooled analysis, maximum grain yield (1912 kg ha^{-1}) was attained with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS which was at par with weed free treatment and PE pendimethalin @ 0.75 kg a.i. ha^{-1} followed by one hand weeding at 60 DAS (1759) and significantly higher as compared to all other weed management practices.

Table 2: Residual effect of weed management practices on grain yield (kg ha^{-1}) and biological yield (kg ha^{-1}) of chickpea during 2018-19, 2019-20 and pooled

Treatment	Grain yield (kg ha^{-1})			Biological yield (kg ha^{-1})		
	2018-19	2019-20	Pooled mean	2018-19	2019-20	Pooled mean
T_1	1735	1782	1759	4239	4326	4283
T_2	1679	1739	1709	4168	4231	4199
T_3	1566	1598	1582	4029	3955	3992
T_4	18 96	1927	1912	4442	4517	4479
T_5	1603	1636	1619	4070	4007	4038
T_6	1843	1976	1910	4493	4625	4559
T_7	1188	1217	1202	3591	3668	3629
S.E. (m) +	76.19	97.10	65.12	87.55	130.55	89.50
C.D. at 5%	234.77	299.18	200.66	269.78	402.26	275.79
General mean	1644	1696	1670	4147	4190	4168

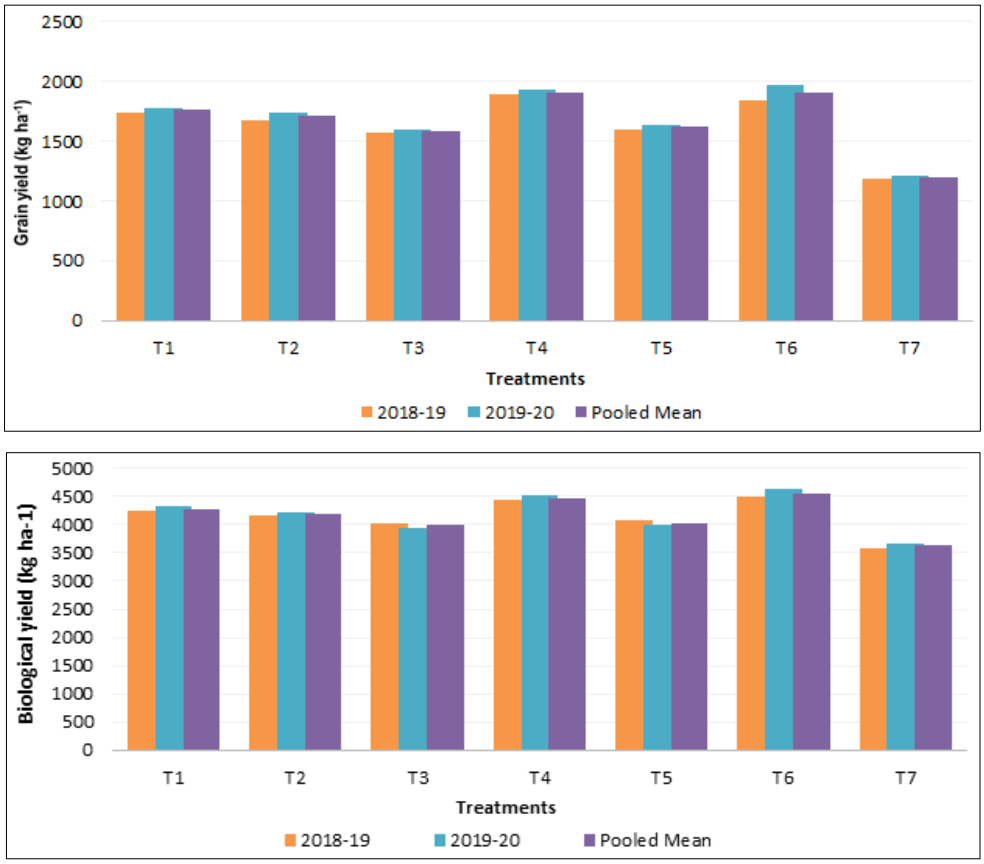

Fig 2: Residual effect of weed management practices on grain yield (kg ha^{-1}) and biological yield (kg ha^{-1}) of chickpea during 2018-19, 2019-20 and pooled

Biological yield

The data pertaining to chickpea biological yield (kg ha^{-1}) is depicted in Table 2. Chickpea biological yield (kg ha^{-1}) was significantly influenced by residual effect of weed management practices. Maximum biological yield (kg ha^{-1}) of 4493 and 4625 was attained with weed free treatment which was at par with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS (4442 and 4517) and PE pendimethalin @ 0.75 kg a.i. ha^{-1} followed by one hand weeding at 60 DAS (4239 and 4326) and significantly higher as compared to all other weed management practices in 2018-19 and 2019-20, respectively. The lowest biological yield of 3591 and 3668 (kg ha^{-1}) was obtained with weedy check during 2018-19 and 2019-20, respectively. In pooled analysis, maximum biological yield (kg ha^{-1}) of 4559 was attained with weed free treatment which was at par with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS and significantly higher as compared to all other weed management practices during 2018-19 and 2019-20, respectively.

Harvest index

Significantly highest harvest index (42.72%) was observed with POE pyrithiobac sodium @ 62.5g a.i. ha^{-1} + quizalofop ethyl @ 50 g a.i. ha^{-1} at 30 DAS followed by one hand weeding at 60 DAS which was at par with all other treatments except it was significantly higher as compared to weedy check in 2018-19. In 2019-20, highest harvest index (42.70%) was obtained with weed free treatment and was at par with all other treatments except it was significantly higher as compared to weedy check. In pooled data, highest harvest index (41.86%) was observed with weed free which was at par with all other treatments except it was significantly higher as compared to weedy check.

Table 3: Residual effect of weed management practices on harvest index (%) of chickpea during 2018-19, 2019-20 and pooled

Treatment	Harvest index (%)		
	2018-19	2019-20	Pooled mean
T_1	40.92	41.22	41.07
T_2	40.29	41.11	40.70
T_3	38.83	40.32	39.58
T_4	42.72	42.64	42.68
T_5	39.32	40.76	40.04
T_6	41.02	42.70	41.86
T_7	33.07	33.10	33.09
S.E. (m) +	1.50	1.68	1.13
C.D. at 5%	4.61	5.18	3.48
General mean	39.45	40.26	39.86

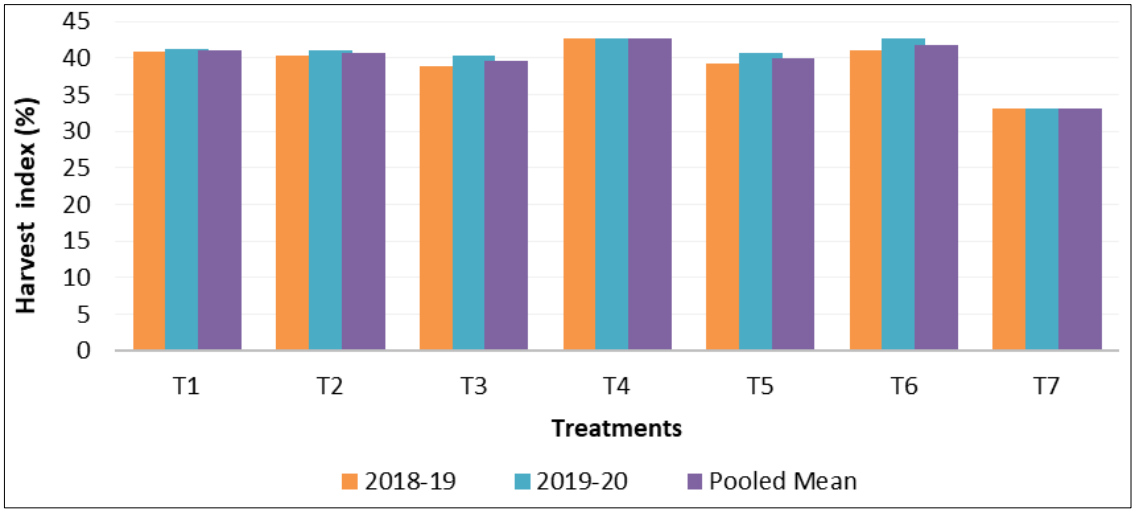

Fig 3: Residual effect of weed management practices on harvest index (%) of chickpea during 2018-19, 2019-20 and pooled

Based on two years of investigation, it is concluded that POE pyrithiobac sodium @ 62.5g ai/ha + quizalofopethyl @ 50 g ai/ha at 30 DAS followed by one hand weeding at 60 DAS recorded maximum yield attributes *viz.* pods plant^{-1}, seed pod-1 and grains pod-1 which in turn resulted in to maximum grain yield, biological yield and harvest index.

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