Available online at www.ijpab.com

DOI: http://dx.doi.org/10.18782/2320-7051.7373

ISSN: 2320 – 7051

Int. J. Pure App. Biosci. **7 (2):** 228-234 (2019)

Research Article

International Journal of Pure & Applied Bioscience

OPEN ACCESS

Bio Efficacy of Diquat Applied In Potato and their Carry over Effect on Succeeding Maize Crop in South Eastern Rajasthan

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Received: 11.03.2019 | Revised: 15.04.2019 | Accepted: 21.04.2019

ABSTRACT

A field experiment was conducted at Agricultural Research Station, Kota, Rajasthan during rainy (Rabi) season of 2015-16 and 2016-17, to evaluate bio efficacy of diquat applied in potato and their carry over effect on succeeding maize crop in south eastern Rajasthan. Treatments included pre post emergence application of diquat 20 % SL @ 0.5 to 2.4 kg a.i/ha, Paraquat dichloride 24 % SL @ 0.24 kg a.i/ha, two hand weeding at 80 and 100 DAS and weedy check, and was laid out in randomized block design with three replications. The pooled data of two years revealed that application of diquat @ 0.7 kg a.i/ha resulted in significantly higher weed control efficiency, plant height, shoots/plant, biomass production at 90 DAS and at harvest, tubers/plant, tuber yield, straw yield, net return and B:C ratio. The higher yield of "C" grade (0-25g) and "D" grade (>75g) tubers were recorded with early post emergent application of diquat 20 % SL @ 0.7 kg a.i./ha and "C" grade (25-50g) with diquat 20 % SL @ 0.5 kg a.i./ha. However, maximum tuber yield of "A" grade (0-25g) was noticed with diquat 20 % SL @ 2.4 kg a.i./ha fb diquat 20 % SL @ 1.2 kg a.i./ha. Residual effect of diquat 20 % SL on succeeding crop maize was not seen.

Key word: *Bio efficacy, Crop production, Potato, Diquat, Maize, Weed control*

INTRODUCTION

Potato (*Solanum tuberosum* L.) is regarded as "Future Food Crop" by Food and Agriculture Organization owing to its remarkable potential of producing highest food, energy and protein per unit area and time. It is a popular temperate crop and is largely grown during winter season in India. Due to its initially slow growing, it is heavily infested with many grassy and broad-leaved weeds, which compete with the crop during initial growth stage resulting in reduced tuber yield of potato**.** In India, weeds are one of the major biological constraints that limit crop productivity. They compete with crops for natural and applied resources besides being responsible for reducing quantity and quality of agricultural productivity.

Cite this article: Narolia, R.S., Meena, B.S., Nagar, B.L. and Verma, A.K., Bio Efficacy of Diquat Applied in Potato and Their Carry over Effect on Succeeding Maize Crop in South Eastern Rajasthan, *Int. J. Pure App. Biosci.* **7(2):** 228-234 (2019). doi: http://dx.doi.org/10.18782/2320-7051.7373

In other studies, weeds were reported to cause up to one-third of the total losses in yield, besides impairing quality of produce and causing health and environmental hazards. Losses of this magnitude due to weeds may occur in vegetables and the total economic losses will be much higher, if indirect effects of weeds on health, losses of biodiversity, nutrient depletion, tuber quality, etc. are taken into consideration. Weeds, undesirable plants compete with the early stage of potato establishment and reduce the tuber yield significantly[2]. The yield reduction due to weeds in potato is estimated to be as high as 10 to 80 per cent[7]. So, control of weeds in the initial stages appears imperative as it plays an important role in maximizing the tuber production. Manual weeding has been synonymous with weed management for centuries, due to abundant availability of labour, cheaper labour costs and the nature of agriculture as an occupation. Hence, manual and mechanical methods were the prevalent weed management techniques used by farmers. The effect of increased wages and labour costs has concomitantly increased reliance on herbicides, applied alone or as a component of integrated weed management (IWM).Therefore, present study was planned to evaluate bio efficacy of Diquat in potato and their carry over effect on succeeding maize in south eastern Rajasthan

MATERIAL AND METHODS

The field experiment was conducted during *Rabi* seasons of 2015-16 & 2016-17 at Agricultural Research Station, Kota (26º North latitude, 76º-6' East longitude and 260 m above mean sea level), Rajasthan. The study area falls under humid south eastern plain zone of Rajasthan. The soil of the experimental field was in order of vertisols having bulk density 1.50 Mg/m^3, pH 7.76 and Cation exchange capacity 35 Cmol/kg. The soil had a very low infiltration rate (0.25 cm/hr) on surface but at deeper layer (1.2 to 1.5 m) was impermeable. The potential moisture retention capacity of soil is 120 mm of water in 1 m depth. The soil of the experimental field was medium in organic carbon 5.4 g/kg, available nitrogen (281 kg/ha), available phosphate (22.7 kg P_2O_5/ha) and high in available potash (316 kg K_2O /ha). The maximum and minimum temperature during the potato crop period ranged 37.4^0C &6.8^0C in 2015-16 and 39.4^0C& 4.8^0C in 2016-17, respectively and the total rainfall received during the crop season was only 21.4 mm in 2016-17. Whereas, maximum and minimum temperature during the succeeding maize crop period ranged 36.3^0C &20.9^0C in 2016 and 34.6^0C& 14.6^0C in 2017, respectively and the total rainfall received during the crop season was 1041.8 and 366.0 mm in 2016 and 2017, respectively.

The experiment was laid out in randomized block design with 3 replications. Treatments comprised *viz*; *viz*. T_1**:** Diquat 20 % SL @ 0.5 kg a.i/ha, T_2**:** Diquat 20 % SL @ 0.7 kg a.i/ha, T_3**:** Diquat 20 % SL @ 1.2 kg a.i/ha, T_4**:** Diquat 20 % SL @ 2.4 kg a.i/ha, T_5**:** Paraquat dichloride 24 **%** SL @0.24 kg a.i/ha, T_6**:** Two hand weeding at 80 and 100 DAS and T_7**:** Weedy check (unweeded). All the herbicides were applied as early post emergence (EPE) *i.e.* early post emergence between row application at 5-10 % emergence or maximum height of 15 cm of potato. Recommended package of practices viz. high yielding variety (Kuphari Khyati), crop geometry (60 cm x 15 cm), seed rate (30 q/ha), seed treatment, recommended dose of fertilizer (187.5:125:125: NPK. Potato seed tubers of 25-30 mm size were sown 5 cm deep on the south side of the ridges at the spacing of 15 cm between tubers. The crop was sown on 9 and 18 November, 2015 and 2016 & harvested on 17 and 15 March in 2016 and 2017. All the plant protection measures were adopted to ensure healthy crop. Basal application of nitrogen and full doses of P and K were applied through diammonium phosphate and muriate of potash, respectively. The remaining nitrogen was top dressed as urea in two equal splits at brancing and before tuber initiation stage. A common basal dose of zinc sulphate

(21 % Zn) @25 kg/ha was applied uniformely to all the plots. The required quantity of herbicide as per treatment was applied with manually operated knapsack sprayer using a spray volume of 500 liter water/ha. Sufficient moisture was kept in the field at the time of application of herbicides. Two irrigations were applied at branching and tuber development stage of potato crop. Weed density (number/m^2) and weed dry weight (g/m^2) were measured from the randomly selected samples at 2 places in each plot with the help of 0.25 m^2 quadrates at 14 and 30 days after sowing and separated for grassy, sedges and broad leaves. Weed control efficiency (WCE) was also calculated on the basis of dry-matter production of weeds. Data were transformed using $\sqrt{X+0.5}$ before statistical analysis. Samples were oven dried at 70^0C for 72 hr and dry weight was recorded. Plant height of potato was measured from the base of the plant at ground surface to the tip of the tallest leaf using meter scale. Branches/plant was noted by counting from sampling unit at harvesting stage. Biomass production was recorded in one meter square area of each plot at 90 DAS and at harvest. Straw yield was obtained by dehaulmed sun dried bundle from each plot. After haulming, potato tubers were dug out from the randomly selected samples at 2 places in each plot for recording of tubers/plant. Tuber yield was recorded and then graded in 0-25g, 25-50g, 50-75g and >75g. Tuber yield was expressed in q/ha. Gross and net returns were calculated based on the tuber and straw yield and prevailing market prices of potato in respective seasons. The benefit: cost ratio was calculated by dividing the net returns from the total cost of cultivation. All the observation were statistically analysed for its test of significance of the individual years and pooled over years through standard procedures. The results have been discussed at the probability level of five per cent. The level of significance used in "F" and "t" test was p=0.05. Critical difference values were calculated whenever the "F" test was significant[6]. To study persistence/phyto-toxicity of herbicides, maize was sown with 20 kg/ha seed rate in *Kharif* season of 2016 and 2017 as succeeding crop after harvesting of potato crop. Maize crop was raised as irrigated condition with full package of practices and harvested to record yield attributes and yield.

RESULTS AND DISCUSSIONS

Weeds

During investigation, potato crop was infested mainly with *Cynodon dactylon* (L.), Pers *Chenopodium album*, *Convolvulus arvensis*, *Cyperus rotundus* (L.), *Fumaria parviflora*, *Medicago denticulate*, *Melilotus alba*, *Rumex dentatus* and *Spergula arvensis*. All the weed control treatment substantially reduced the weed count and their dry weight of grassy, sedge and broad leaf weeds at 7 and 14 days after planting (DAS) of observations as compared to weedy check (Table 1). Significantly lower weed count (17.5,26.6,21.9 & 13.5,20.6,16.9) and their total dry weight (10.78,13.03 g/ha) and highest weed control efficiency (82.92,82.93 %) of grassy, sedge and broad leaf weeds at both the stages of observations were recorded with the application of diquat 20 % SL @ 0.7 kg a.i/ha than the weedy check, respectively. However, paraquat dichloride 24 % SL @ 0.24 kg a.i./ha and diquat 20 % SL @ 0.7 kg a.i./ha remained statistically at with each other in relation to least weed density, their total dry weight and higher weed control efficiency at both the stages of the observations. The highest weed control efficiency may be due to effective control of weeds which indicated lower weed count and their dry weight at different stages of observations. The variation in weed count and their dry weight and weed control efficiency might be due to differences in effectiveness of herbicides against weeds in field. The similar results were also reported by Hoogar *et al*.[7].

Growth and yield attributes

A perusal of data (Table 2) revealed that application of graded dose of diquat 20 % SL @ 0.5 to 2.4 kg a.i./ha had significant effect on plant height at 45 DAS and harvest,

shoots/plant, biomass production at 90 DAS and harvest and tubers/plant of the potato but did not affect on plant population at 45 DAS and at harvest. . Though, application of diquat 20 % SL @ 0.7 kg a.i./ha was recorded significantly tallest plant (57.3,60.1 cm), plant biomass (675, 2363 kg/ha) recorded at 90 DAS and at harvest over lower dose of diquat 20 % SL @ 0.5 kg a.i./ha and weedy check. However, diquat 20 % SL @ 0.7 kg a.i./ha and paraquat dichloride 24 % SL @ 0.5 kg a.i./ha remained statistically on par with each other in relation to plant height, branches/plant and biomass production at 90 DAS and harvest resulted diquat 20 % SL @ 0.7 kg a.i./ha or Paraquat dichloride 24 % SL @ 0.5 kg a.i./ha proved effective for managing weed competition in potato compared to weedy check. This was owing to significant reduction in weed density and weed dry weight. Effective control of weeds with diquat 20 % SL @ 0.7 kg a.i./ha as early post emergence application (EPE) might have resulted in growth and yield attributing characters of the potato crop, which reduces the water and nutrients uptake by weeds. Severe weed infestation decreased the growth and yield attributes in weedy check. These results are in accordance with the finding of Sitangshu and Majumdar[4].

Yields

Application of graded dose of diquat 20 % SL @ 0.5 to 2.4 kg a.i./ha also had significant effect on tuber and straw yield of potato (Table 3).Application of diquat 20 % SL @ 0.7 kg a.i./ha as early post emergence recorded significantly higher tuber yield (221 q/ha) and straw yield (23.6 q/ha). However, diquat 20 % SL @ 0.7 kg a.i./ha and paraquat dichloride 24 % SL @ 0.5 kg a.i./ha remained statistically on par with each other in relation to enhance tuber and straw yield . Weed management practices did not influence on harvest index. Higher tuber yield was attributed to better control of weeds and higher weed control efficiency (82.92 %) throughout the crop growth period, which resulted in better availability of growth factors like light, space, nutrients and moisture to the potato crop resulting in better crop growth and yield. The higher yield of "C" grade (0--25g) and "D" grade (>75g) tubers were recorded with early post emergent application of diquat 20 % SL @ 0.7 kg a.i./ha and "C" grade (25-50g) with diquat 20 % SL @ 0.5 kg a.i./ha. However, maximum tuber yield of "A" grade were noticed with diquat 20 % SL @ 2.4 kg a.i./ha fb diquat 20 % SL @ 1.2 kg a.i./ha. The minimum yield and yield attributes in unweeded check were the result of severe weed competition. These findings are in confirmatory with the work of Chitsaz and Nelson[1]. and Janaki *et al*.[3].

Economics

Implication of any weed management practices results in better monetary return when compared with weedy check (Table 3). Unweeded control was observed as a futile practice, as it gave only Rs. 123065/ha. Application of diquat 20 % SL @ 0.7 kg a.i./ha resulted in significantly maximum net return (Rs. 208448/ha) and B:C ratio (6.62) than other doses of diquat. However, paraquat dichloride 24 % SL @ 0.24 kg a.i./ha and diquat 20 % SL @ 0.7 kg a.i./ha remained statistically at with each other in relation to net return and B:C ratio. The lowest net return and B:C ratio obtained in weedy check were due to high infestation of weeds resulting in low weed control efficiency. These results are in conformity with those reported by Hoogar *et al*.[7].

Residual effect of herbicides

Application of diquat @ 0.5 to 2.4 kg a.i/ha in potato crop as pre post emergence did not have any adverse effect on succeeding maize crop in relation to yield attributes and yield (Table 4). The similar results were also reported by Janaki *et al*.[2], and Mukharjee, *et al*.[8].

Table 1: Effect of herbicides application on weed count, dry weight and weed control efficiency in potato (Pooled data of 2016 & 2017)

Treatment	Weed count (Nos/m^2)						Total dry weight (g/m^2)		Weed control efficiency (%)	
	14 DAA			30 DAS			14 DAA	30 DAA	14 DAA	30 DAA
	Grassy	Sedge	Broad leaf	Grassy	Sedge	Broad leaf				
Diquat 20 % SL @ 0.5 kg a.i/ha	23.2	35.3	29.1	18.6	28.2	23.2	12.97	15.18	79.36	79.48
Diquat 20 % SL @ 0.7 kg a.i/ha	17.5	26.6	21.9	13.5	20.6	16.9	10.78	13.03	82.92	82.93
Diquat 20 % SL @ 1.2 kg a.i/ha	16.9	25.6	21.1	13.0	19.7	16.3	10.73	12.89	83.05	83.03
Diquat 20 % SL @ 2.4 kg a.i/ha	16.6	25.1	20.8	12.6	19.1	15.8	10.58	12.97	83.48	83.29
Paraquat Dichloride 24 % SL @ 0.24 kg a.i/ha	18.1	27.6	22.8	13.5	20.6	16.9	11.01	13.28	82.60	82.59
Hand weeding twice at 80 & 100 DAS	144.4	219.7	181.0	132.5	201.5	166.0	62.14	80.08	100.0	100.0
Weedy check	146.0	222.1	182.9	133.8	203.5	167.7	63.22	81.26	0.00	0.00
SEm±	1.50	1.45	1.26	1.37	1.22	1.70	0.62	0.84	0.32	0.27
C.D. (P=0.05)	4.39	4.23	3.68	4.0	3.55	4.97	1.82	2.44	1.00	0.80

DAA= days after application of herbicides

Table 2: Effect of herbicides application on growth and yield attributes of direct seeded rice (Pooled data of 2016 & 2017)

Treatment	Plant population/m^2		Plant height (cm)		Shoots/plant		Biomass production (kg/ha)		Tuber s/plant
	45 DAS	Harvest	90 DAS	Harvest	90 DAS	Harvest	90 DAS	Harvest	
Diquat 20 % SL @ 0.5 kg a.i/ha	9.7	8.65	53.4	56.1	2.86	2.85	465	2231	8.43
Diquat 20 % SL @ 0.7 kg a.i/ha	10.5	9.71	57.3	60.1	3.10	3.10	675	2363	10.39
Diquat 20 % SL @ 1.2 kg a.i/ha	10.1	8.66	56.4	59.2	2.67	2.65	713	2229	7.96
Diquat 20 % SL @ 2.4 kg a.i/ha	9.6	7.80	55.6	58.5	2.46	2.44	670	2175	7.72
Paraquat Dichloride 24 % SL @ 0.24 kg a.i/ha	10.6	8.90	57.6	60.3	3.05	3.03	740	2370	10.21
Hand weeding twice at 80 & 100 DAS	10.4	8.80	42.4	47.4	2.45	2.45	360	2431	9.13
Weedy check	9.5	8.25	40.7	40.8	3.30	2.30	273	2070	6.82
SEm±	0.052	0.054	1.68	1.85	0.20	0.18	6.84	57.5	0.67
C.D. (P=0.05)	NS	NS	4.90	5.39	0.59	0.52	19.97	167.8	1.96

Table 3: Effect of herbicides application on test weight, grain and straw yield, net return and B: C ratio of direct seeded rice (Pooled data of 2016 & 2017)

Treatment	Tuber grading (q/ha)				Tuber yield (q/ha)	Straw yield (q/ha)	HI	Gross return	Net return	B:C ratio
	A 0-25 (g)	B 25-50 (g)	C 50-75 (g)	D > 75 (g)			(%)	(Rs./ha)	(Rs./ha)	
Diquat 20 % SL @ 0.5 kg a.i/ha	45	71	62	25	203	22.3	90.0	219700	188715	6.09
Diquat 20 % SL @ 0.7 kg a.i/ha	45	50	84	43	221	23.6	90.3	239933	208448	6.62
Diquat 20 % SL @ 1.2 kg a.i/ha	84	42	45	22	192	22.3	89.4	207533	174798	5.34
Diquat 20 % SL @ 2.4 kg a.i/ha	94	39	38	17	187	21.8	89.4	201867	166132	4.65
Paraquat Dichloride 24 % SL @ 0.24 kg a.i/ha	42	50	70	45	206	23.7	89.6	223233	192298	6.22
Hand weeding twice at 80 & 100 DAS	37	55	53	19	164	24.3	86.8	176700	142865	4.23
Weedy check	90	20	18	15	141	19.5	87.4	151900	123065	4.27
SEm+	6.82	4.42	5.47	3.03	5.43	0.40	-	5852	5852	0.180
C.D. (P=0.05)	19.9	12.9	16.0	8.8	15.9	1.17	NS	17078	17078	0.52

Table 4: Residual effect of herbicides application on growth, yield attributes and yields of succeeding crop maize (Pooled data of 2016 & 2017)

Treatment	Germination (%)	Plant height (cm)		Dry matter (q/ha)	Cob length (cm)	Grains/Cob	Seed index (g)	Straw yield (q/ha)	Grain yield (q/ha)
		30 DAS	Harvest	Harvest					
Diquat 20 % SL @ 0.5 kg a.i/ha	91	35.13	179.1	114.4	6.69	475	23.03	84.4	31.4
Diquat 20 % SL @ 0.7 kg a.i/ha	91	35.07	181.9	115.6	6.83	499	23.17	85.6	32.0
Diquat 20 % SL @ 1.2 kg a.i/ha	90	35.53	181.3	114.5	6.69	470	22.87	84.5	31.6
Diquat 20 % SL @ 2.4 kg a.i/ha	89	37.07	180.9	115.2	6.71	470	22.85	84.9	30.4
Paraquat Dichloride 24 % SL @ 0.24 kg a.i/ha	91	35.04	182.1	115.8	6.87	478	23.12	85.8	31.9
Hand weeding twice at 80 & 100 DAS	91	35.70	182.5	114.6	6.75	470	23.20	84.6	31.7
Weedy check	90	34.56	179.2	113.7	6.56	441	22.74	83.7	31.7
SEm+	-	-	-	-	-	-	-	-	-
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

CONCLUSION

On the basis of two years study, it could be concluded that in potato-maize cropping sequence, weeds in potato can be managed by early post emergence application of diquat @ 0.7 kg a.i/ha between row application at 5-10 % emergence or maximum height of 15 cm of potato without any harmful carry over effect on the succeeding maize crop.

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