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Studies on 2, 4-D dimethylamine 58% SL to control different weeds in wheat and its effect on succeeding black gram crop

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Abstract

The experiment was conducted during Rabi season of 2013-14 and summer season of 2014 at Regional Research Station, New Alluvial Zone, Chakdaha, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India to disclose the bio-efficacy and phytotoxicity of 2, 4-D dimethylamine 58% SL in wheat and its effect on succeeding crop blackgram. The field trial consisting of eight different treatments and laid out in randomized block design with three replications. Application of 2, 4-D dimethylamine 58% SL 1 kg a.i. $ha^{-1}$and 2, 4-D dimethylamine 58% SL 0.75 kg a.i. ha^{-1} have resulted in effective weed control, and contributed in significantly high grain yield of wheat and no phytotoxicity was observed through these applied treatments which were statistically comparable to hand weeding twice. The said treatments were statistically superior to two round of hand weeding and other doses of 2, 4-D dimethylamine 58% SL. 2, 4-D dimethylamine 58% SL applied on wheat with different doses have found no residual effect on germination and yield of succeeding blackgram crop. So, these treatments can be a good option for wheat and succeeding black gram crop under sub-humid and subtropical condition of West Bengal.

Keywords: 2, 4-D dimethylamine 58% SL, bio-efficacy, phytotoxicity, wheat, succeeding black gram crop

Introduction

Wheat (*Triticum aestivum* L.) is one of the most important cereal crops grown in India across the exceptionally diverse range of environments (Goswami *et al.*, 2020a) [6]. India is the second largest producer of wheat, accounting 12 percent of the global production (Kundu *et al.*, 2020a) [9]. Wheat production reached to 102.19 million tones with an approximate national productivity of 3,371 kg ha^{-1} during 2019 (Director's Report 2019, IIWBR, Karnal) [3]. But for West Bengal, wheat contributes only 5.15% to the total food grain production and 3.1% to national production. Besides wheat, a significant cereal crop, pulses have taken place as a source of supplementary protein to daily diets for a predominantly vegetarian population and for those who cannot afford expensive animal protein (Goswami *et al.*, 2020b) [5]. Blackgram (*Vigna mungo* L.) is an important highly priced and phosphoric acid rich pulse crop grown in India. Currently, India represents the largest producer (3560 Thousand Tonnes, Directorate of Economics and Statistics, 2017-18) [2] of blackgram accounting for more than 70% of the global production. Hence, there is an urgent need to increase wheat and blackgram productivity in order to meet the food requirements of this region, realizing rapid population growth and dietary preference of Bengal people. Among the different factors which adversely impact the productivity of wheat and blackgram crop, weed infestation is the most harmful one but less noticeable. Weeds can only incur a grain yield loss of 48 percent in wheat (Khan and Haq, 2002) [7]. However, the magnitude of weed-related losses depends on the type and density of a particular weed species, its time of emergence and the duration of the interference (Fahad *et al.*, 2015) [4]. Blackgram also is not a very good competitor against weeds (Choudhary *et al.*, 2012) [1], in general, yield loss due to uncontrolled weed growth in blackgram ranges from 27 to 100% (Singh and Singh, 2010) [13]. Identification of new herbicides is vital and urgently needed to reduce the possibility of evolution of resistant biotype of weeds and getting higher wheat yield. 2, 4-D dimethylamine is such an exigent selective herbicide in cereals crop which kills many grassy and broadleaf weeds (Kundu *et al.*, 2020b) [10]. 2, 4-D is a systemic herbicide that is absorbed through foliage and roots and is translocated to actively growing areas within the plant. In this circumstance, standardization and evaluation of 2, 4-D dimethylamine is crucial for getting higher wheat productivity and recovery over and again.

Therefore, here, the present experiment was conducted to test the bio-efficacy and phytotoxicity of this herbicide molecule used in wheat field for weed management and its effect on following crop blackgram.

Materials and Methods

The experiment was conducted during winter seasons of 2013-14 at Regional Research Station, Chakdaha under Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal (23^0 07'N latitude, 88 ^{0} 52' E longitude, 9.75 m above mean sea level) to study the bio-efficacy and phytotoxicity of 2, 4-D dimethylamine 58% SL in Wheat and its effect on succeeding crop blackgram in medium land under sub-humid and sub-tropical condition of West Bengal. Soil at the experimental site (0-15 cm depth) was loamy in texture containing 52.65% sand, 26.2% silt and 21.15% clay with 6.54 pH and 0.57% organic carbon (OC). Available N, P_2O_5 and K_2O contents were 194.6, 47.2 and 198.2 kg/ha, respectively. The experiment was laid down in randomized block design with three replications comprised with eight different treatment combinations where four different doses of 2,4-D dimethylamine 58% SL(Nufarm) applied at 0.25, 0.50, 0.75, and 1.0 kg a.i. ha^{-1}, 2, 4-D dimethylamine 58% SL(Commercial) with dose 0.50 kg a.i. ha^{-1}, Metsulfuron methyl 20% WP with dose 0.004 kg a.i. ha^{-1}, two hand weeding at 20 days after sowing and 40 days after sowing and unweeded control, respectively. The seeds of wheat variety 'PBW-343' were sown 20 cm apart from one row to another row while maintaining 5-7 cm plant to plant distance in the plots of 5.0 m × 4.0 m area. Dropping of seeds with maintaining of 100 kg/ha seed rate were done manually at a depth of 2-3 cm below the soil surface with the help of hand tynes and covered properly with soils. All the herbicides were applied as solution in water at the rate of 500 litres/ha. The herbicide solutions were sprayed uniformly in the experimental plots as per treatments with the help of knapsack sprayer fitted with flat fan nozzle. For counting of weed population and weed biomass, required number of permanent quadrates (0.5 m x 0.5 m) was specified in each plot. Total weed population was measured as the number of weeds per unit area at 20, 40 and 60 days after sowing from the quadrates according to the weed species in situ. For taking weed biomass or weed dry matter, the destructed weed samples were first washed in clean tap water, then sun-dried and hot-air oven-dried at 70°C for 48 h, and weighed. Along with these, effect of different treatments on population of broad leaf weeds, on population of sedges and grasses, weed control efficiency (WCE) were measured. Weed control efficiency (%).

$$\text{Weed control efficiency (\%)} = \frac{(WDM_c - WDM_t)}{WDM_c} \times 100$$

where, WDM_c = Weed dry weight in control plot & WDM_t = Weed dry weight in treated plot. On the other hand, effect of treatments in the grain yield, straw yield and harvest index were recorded (Kundu *et al.*, 2020c) [11].

The observation on visual crop toxicity was done on 7, 14 and 21 days after herbicide application (DAHA) by visual assessment based on Phytotoxicity Rating Scale (PRS) 0 to 10, where 0 = No crop injury, while 10 = Heavy injury or complete destruction of test crop. The visual crop toxicity symptoms like leaf injury, vein clearing, epinasty or hyponasty, scorching and necrosis were observed. Succeeding crop blackgram was taken during summer season of 2014 to find out the residual effects of herbicides 2, 4-D dimethylamine 58% SL and Metsulfuron Methyl 20% WP. Blackgram variety 'Kalindi' (B-76) was sown in rows 25 cm apart (individual plot size was 5 m x 4 m) using 25 kg seeds ha^{-1} on 23rd March, 2014. These studies were continued in fixed layout without disturbing the soil. The weeds were removed manually in these crops. Observations on germination percent at 10 DAS (days after sowing) of the succeeding blackgram crop was recorded during the experiment. The total yield of succeeding crop was recorded at the time of harvest.

Result and Discussion

Effect on weed density

The experimental field was utterly infested with diversified weed flora consisting of both dicots and monocots (Table 1, 2). It was observed that the population of broad leaf weed, grassy weeds and sedges varied significantly due to weed control treatments. In the crowd of miscellaneous weed flora, the experimental field was dominated by *Chenopodium album, Cirsium arvense, Fumaria parviflora, Anagallis arvensis, Cyperus rotundus, Cyperus iria Phalaris minor, Cynodon dactylon* and *Avena fatua* irrespective of the dates of observations, before as well as 20, 40 and 60 days after herbicide application. The weedy plots were infested with the highest densities of above weed species at all dates of observations. Data revealed significant reduction in total weed density in the herbicide treatments (Table 3). The total weed density was significantly reduced in the herbicide treatments. The data on weed count has revealed that 2, 4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} has resulted in effective control of all type of weeds and has recorded least weed count at 20, 40 and 60 DAS and remained at par among themselves and superior to the other treatments except two hand weeding twice. 2, 4 - D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} was on par with 2, 4-D dimethylamine 58% SL 0.75 kg a.i. ha^{-1} in controlling the total weed population. The unweeded control treatment recorded the highest weed count at all the observations with the pre-dominance of broad leaf weeds followed by sedges and grasses, respectively. Application of 2, 4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} was proved to control individual weed species *viz*., *Chenopodium album*, *Cirsium arvense*, *Fumaria parviflora*, *Anagallis arvensis* in broad leaved weeds, *Cyperus rotundus*, *Cyperus iria* in sedges and *Phalaris minor*, *Cynodon dactylon*, *Avena fatua* in grasses at all the stages of observation. These consequences are in conformity with the research findings of Labar *et al*., 2017 [12] where it was revealed that higher dose of 2, 4-D dimethylamine 58% SL has resulted in effective control of all type of weeds and has recorded least weed population at 20, 40 and 60 DAS and remained on par among themselves and superior to the other treatments except hand weeding.

Table 1: Effect of treatments on population of broadleaved weeds (No.m^{-2}) in wheat

Tr. No.	Treatment	Dose a.i. kg ha^{-1}	Broadleaved weeds											
			Chenopodium album			*Cirsium arvense*			*Fumaria parviflora*			*Anagallis arvensis*		
			20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T_1	2,4-D dimethylamine 58% SL (Nufarm)	0.25	1.43	1.85	2.74	0.40	0.49	0.52	0.94	1.56	2.09	0.75	0.97	1.81
T_2	2,4-D dimethylamine 58% SL (Nufarm)	0.50	1.02	1.17	2.37	0.24	0.28	0.18	0.77	0.95	1.63	0.45	0.66	1.12
T_3	2,4-D dimethylamine 58% SL (Nufarm)	0.75	0.85	1.12	2.14	0.20	0.16	0.26	0.74	0.82	1.62	0.40	0.64	1.05
T_4	2,4-D dimethylamine 58% SL (Nufarm)	1.00	0.78	1.10	2.10	0.16	0.14	0.20	0.55	0.72	0.89	0.39	0.46	0.64
T_5	2,4 D dimethylamine 58% SL(Commercial)	0.50	1.04	1.67	2.38	0.25	0.31	0.33	1.04	1.34	1.68	0.48	0.90	1.22
T_6	Metsulfuron methyl 20% WP	0.004	1.27	1.68	2.40	0.38	0.39	0.58	0.80	1.35	1.77	0.72	0.91	1.26
T_7	Hand weeding twice	-	0.43	0.69	0.83	0.07	0.09	0.08	0.32	0.53	0.57	0.20	0.41	0.42
T_8	Unweeded control	-	4.22	6.27	5.75	0.70	1.10	1.09	3.12	5.17	3.97	2.01	3.14	2.87
	SE (d)		0.12	0.23	0.29	0.03	0.04	0.05	0.11	0.19	0.20	0.06	0.11	0.15
	CD (P= 0.05)		0.36	0.66	0.88	0.08	0.13	0.15	0.30	0.56	0.57	0.18	0.33	0.45

Table 2: Effect of treatments on population of sedges and grasses weeds (No.m^{-2}) in wheat

Tr. No.	Treatment	Dose a.i. kg ha^{-1}	Sedges						Grasses								
			Cyperus rotundus			*Cyperus iria*			*Phalaris minor*			*Cynodon dactylon*			*Avena fatua*		
			20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS
T_1	2,4-D dimethylamine 58% SL (Nufarm)	0.25	2.05	3.21	4.07	1.23	2.33	2.82	1.58	2.23	3.68	0.62	0.95	1.60	1.02	1.34	2.72
T_2	2,4-D dimethylamine 58% SL (Nufarm)	0.50	1.46	2.02	3.63	1.01	1.32	2.18	1.05	1.64	2.67	0.44	0.78	0.80	0.64	1.06	1.52
T_3	2,4-D dimethylamine 58% SL (Nufarm)	0.75	1.46	1.76	3.33	0.99	1.29	2.13	0.69	1.60	2.30	0.22	0.77	0.73	0.45	0.99	1.33
T_4	2,4-D dimethylamine 58% SL (Nufarm)	1.00	1.31	1.69	2.86	0.93	0.95	2.07	0.61	1.04	1.43	0.19	0.27	0.58	0.38	0.65	1.04
T_5	2,4 D dimethylamine 58% SL(Commercial)	0.50	1.68	2.18	3.87	1.16	1.43	2.22	1.09	1.69	2.99	0.45	0.80	0.96	0.66	1.18	1.92
T_6	Metsulfuron methyl 20% WP	0.004	1.78	2.65	3.94	1.11	1.78	2.32	1.31	2.04	3.62	0.58	0.80	1.05	0.91	1.24	2.25
T_7	Hand weeding twice	-	0.78	0.74	1.10	0.42	0.53	0.67	0.71	0.85	1.01	0.26	0.15	0.47	0.45	0.54	0.77
T_8	Unweeded control		5.76	9.77	10.75	3.68	5.49	8.80	4.93	6.07	8.60	2.63	2.18	2.66	3.40	3.21	4.38
	SE (d)		0.17	0.34	0.50	0.13	0.22	0.34	0.12	0.23	0.39	0.06	0.09	0.13	0.11	0.14	0.22
	CD (P= 0.05)		0.53	1.03	1.47	0.38	0.65	1.00	0.36	0.67	1.16	0.17	0.26	0.39	0.31	0.40	0.65

Table 3: Effect of treatments on total weed population, weed dry matter, weed control efficiency, phytotoxicity and yield of wheat

Tr. No.	Treatment	Dose a.i. kg ha^{-1}	Total weed population (No.m^{-2})			Weed dry matter production (g m^{-2})			Weed control efficiency (%)			Phytotoxicity observation			Yield (t ha^{-1})	
			20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	20 DAS	40 DAS	60 DAS	7 DAHA	14 DAHA	21 DAHA	Grain	Straw
T_1	2,4-D dimethylamine 58% SL (Nufarm)	0.25	2.87	4.50	6.50	1.55	2.27	3.90	78.83	72.04	45.38	0	0	0	1.95	2.89
T_2	2,4-D dimethylamine 58% SL (Nufarm)	0.50	2.63	3.15	5.47	1.26	2.00	3.10	82.79	75.37	56.58	0	0	0	2.05	3.00
T_3	2,4-D dimethylamine 58% SL (Nufarm)	0.75	1.96	3.10	5.14	1.20	1.99	2.92	83.61	75.49	59.10	0	0	0	2.08	3.12
T_4	2,4-D dimethylamine 58% SL (Nufarm)	1.00	1.87	2.51	4.84	1.02	1.49	2.79	86.07	81.65	60.92	0	0	0	2.51	3.95
T_5	2,4 D dimethylamine 58%SL(Commercial)	0.50	2.85	4.12	5.87	1.28	2.09	3.11	82.51	74.26	56.44	0	0	0	2.00	2.95
T_6	Metsulfuron methyl 20% WP	0.004	2.85	4.39	6.50	1.40	2.02	3.44	80.87	75.12	51.82	0	0	0	2.00	2.92
T_7	Hand weeding twice	-	1.21	1.51	1.97	0.67	0.85	1.02	90.85	89.53	85.71	0	0	0	2.90	4.10
T_8	Unweeded control	-	10.15	14.13	16.29	7.32	8.12	7.14	0.00	0.00	0.00	0	0	0	1.25	2.05
	SE (d)		0.13	0.52	0.71	0.17	0.29	0.35	-	-	-	-	-	-	0.23	0.33
	CD (P= 0.05)		0.38	1.52	2.30	0.51	0.87	1.15	-	-	-	-	-	-	0.69	0.98

Effect on weed biomass and weed control efficiency

The dry matter production (DMP) of weeds was recorded at 20, 40 and 60 DAS (Table 3). Significant differences in DMP were observed among the treatments at all the stages. At 20, 40 and 60 DAS, the lowest weed biomass of 0.67, 0.85 and 1.02 gm m^{-2} was recorded in hand weeding twice plot followed by 2, 4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} and 2, 4-D dimethylamine 58% SL 0.75 kg a.i. ha^{-1}. Consequent to the lower density of weeds observed in hand weeding twice followed by 2,4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} and 2, 4-D dimethylamine 58% SL 0.75 kg a.i. ha$^{-1.}$ The weed dry weight was recorded least in the aforesaid treatments. The weed dry weight in the aforesaid treatments remained on par among themselves and remain significantly superior to the other treatments at all the stages especially that the standard treatments *viz*., 2, 4-D dimethylamine 58% SL (Commercial) 0.50 kg a.i. ha^{-1} and Metsulfuron methyl 20% WP 0.004 kg a.i. ha^{-1}. The weed control efficiency derived from the weed dry weight revealed that hand weeding twice resulted with the higher weed control efficiency of 90.85, 89.53 and 85.71% during 20, 40 and 60 DAS respectively. This was followed by 2,4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} (86.07, 81.65 and 60.92% at 20, 40 and 60 DAS respectively) and 2,4-D dimethylamine 58% SL 0.75 kg a.i. ha^{-1} (83.61, 75.49 and 59.10% at 20, 40 and 60 DAS respectively). The weed control efficiency of the aforesaid treatments remained comparable with each other and better than other treatments. The lowest WCE was recorded in unweeded control plot. Researchers and Scientists in different years have also proven that WCE reflects the effectiveness of applied weed management treatments in securing yield against weed competition. These results are similar to the findings of Kundu *et al.,* (2018) [8].

Phytotoxicity
The observation on visual crop toxicity was done on 7, 14 and 21 days after herbicide application (DAHA) (Table 3). The visual crop toxicity symptoms like leaf injury, vein clearing, epinasty, hyponasty, scorching and necrosis were observed. There were no crop phytotoxicity symptoms among the different treatments as well as at the highest dose of 2, 4-D dimethylamine 58% SL. These results are similar to the findings of Goswami *et al.,* (2020b) [5].

Effect on yield
Land productivity in terms of grain yield varied significantly among treatment (Table 3). Hand weeding twice recorded the highest grain yield of 2.90 t ha^{-1} which was at par with 2, 4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} (2.51 t ha^{-1}). This was followed by 2, 4-D dimethylamine 58% SL 0.75 kg a.i. ha^{-1} (2.08 t ha^{-1}) and 2, 4-D dimethylamine 58% SL 0.5 kg a.i. ha^{-1} (2.05 t ha^{-1}). There was a strong negative correlation (R^2=0.881) between grain yield and weed dry matter at 60 DAS (Fig. 1). This result clearly highlights the poor competitive ability of wheat with weeds and the need to control them effectively during the whole growing season. Similar to grain yield, straw yield was also influenced due to different weed management practices. Among the different treatments, hand weeding twice recorded the highest straw yield of 4.10 t ha^{-1} which was followed by 2,4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} (3.95 t ha^{-1}) and 2,4-D dimethylamine 58% SL 0.75 kg a.i. ha^{-1} (3.12 t ha^{-1}).

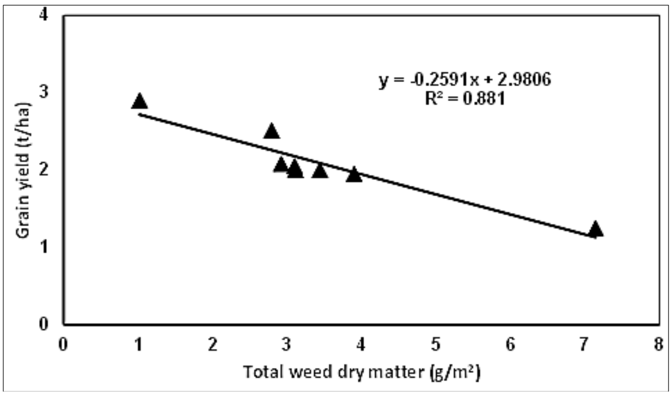

Fig 1: Relationship between grain yield and weed dry matter at 60 DAS

Residual effect of herbicides on succeeding crop black gram
The results regarding germination percentage and yield of succeeding crop blackgram are presented in (Table 4) which revealed that the germination percent of succeeding crop at 10 DAS remain slightly affected irrespective of the treatments. This suggests that best germination obtained in hand weeding twice plot (74.00%) followed by 2, 4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} (72.00%), 2, 4-D dimethylamine 58% SL 0.75 kg a.i. ha^{-1} (72.00%) and 2,4-D dimethylamine 58% SL 0.50 kg a.i. ha^{-1} (72.00%) treatments. Yield of succeeding crop blackgram showed no distinct variation due to the application of different herbicides at varying doses in every experiment for controlling weeds in wheat.

Table 4: Effect of treatments on germination and yield of succeeding crop black gram

Tr. No.	Treatments	Dose a.i. kg/ha	Germination %	Yield (kg ha^{-1})
T_1	2,4-D dimethylamine 58% SL (Nufarm)	0.25	67.00	460
T_2	2,4-D dimethylamine 58% SL (Nufarm)	0.50	72.00	658
T_3	2,4-D dimethylamine 58% SL (Nufarm)	0.75	72.00	666
T_4	2,4-D dimethylamine 58% SL (Nufarm)	1.00	72.00	675
T_5	2,4 D dimethylamine 58% SL(Commercial)	0.50	70.00	566
T_6	Metsulfuron methyl 20% WP	0.004	68.00	552
T_7	Hand weeding twice	-	74.00	693
T_8	Unweeded control		72.00	660
	SE (d)		10.33	0.74
	CD (P = 0.05)		NS	NS

Conclusion
The present investigation conclusively inferred that 2,4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} and 2, 4-D dimethylamine 58% SL 0.75kg a.i. ha^{-1} has resulted in effective weed control, recording the least weed density and weed dry weight and there by higher weed control efficiency after manual weeding twice treatment plot. In case of yield, 2, 4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} and manual weeding twice plot resulted better yield which was on par with aforesaid treatments. 2, 4-D dimethylamine 58% SL tested at different doses for Phytotoxicity has revealed that there is no phytotoxicity symptoms observed in any of the doses and the tested new formulation is safe to the wheat crop. 2, 4-D dimethylamine 58% SL 1.0 kg a.i. ha^{-1} applied in wheat during 2013 on the succeeding crop revealed that there is better impact on either the germination (%) or yield of blackgram crop compare to the other herbicidal doses grown during 2014. Hence, it can be concluded that the aforesaid treatment of this experiment applied in wheat during 2013 is best for succeeding crop blackgram also.

References

1. Choudhary VK, Kumar PS, Bhagawati R. Integrated weed management in blackgram (*Vigna mungo*) under mid hills of Arunachal Pradesh. Indian Journal of Agronomy 2012;57(4):382-385.
2. Commodity profile for Pulses, Annual Report. Directorate of Economics and Statistics 2019, 2017-18.
3. Director’s Report (ICAR). Progress Report (All India Coordinated Research Project) (AICRP) on Wheat and Barley, 2019.
4. Fahad S, Hussain S, Chauhan BS, Saud S, Wu C, Hassan S, Huang J. Weed growth and crop yield loss in wheat as influenced by row spacing and weed emergence times. Crop Pro 2015;71:101-108.
5. Goswami S, Kundu CK, Das S, Khan R, Gunri SK, Das, H. Effect of 2, 4-D Ethyl Ester 80% EC to control weeds in Wheat and its residual effect on succeeding crop Blackgram. International Journal of Chemical Studies 2020;8(5):786-789.
6. Goswami S, Mondal R, Puste AM, Sarkar S, Banerjee H, Jana K. Influence of irrigation and tillage management on growth, yield and water-use efficiency of wheat (*Triticum aestivum*) in Gangetic plains in West Bengal. Indian Journal of Agronomy 2020;65(1):47-52.
7. Khan M, Haq N. Wheat crop yield loss assessment due to weeds. Sarhad J Agric 2002;18:443-457.
8. Kundu A, Kundu CK, Das H, Murmu K, Jana K. Studies on 2, 4-D Dimethylamine 50% SL to Control Weeds in Wheat. Int J Curr Microbiol App Sci 2018;7(9):335-344.
9. Kundu CK, Goswami S, Mondal R, Kundu A. Effect of 2, 4-D ethyl ester 80% EC on weed and yield of wheat in Gangetic plains of West Bengal. Journal of Crop and Weed 2020;16(2):284-289.
10. Kundu CK, Mondal R, Kundu A, Goswami S, Hedayetullah Md. Studies on bio-efficacy and phytotoxicity of different formulation of 2, 4-D amine 50% SL in maize. Journal of Pharmacognosy and Phytochemistry 2020;9(5):559-562.
11. Kundu R, Mondal M, Garai S, Mondal R, Poddar R. Bio-efficacy of post emergence herbicides in boro rice nursery as well as main field and their residuality on no target microorganisms. Oryza 2020;57(3):199-210.
12. Labar A, Kundu CK, Biswas MH, Hedayetullah M, Kole RK, Das SK, Biswas B, Ghosh RK. Bio-efficacy studies of 2, 4-D amine 58% SL in wheat. Journal of Crop and Weed 2017;13(3):200-203.
13. Singh M, Singh RP. Influence of crop establishment methods and weed management practices on yield and economics of direct seeded rice (*Oryza sativa*). Indian Journal of Agronomy 2010;55:224-29.