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Effect of Mulching and Growth Promoters on Weed Dynamics and Growth Attributes in Annual Redgram (*Cajanus cajan* L.)

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A field experiment was conducted at Agricultural College and Research Institute, Madurai during rabi 2009-2010 to study the effect of mulching and foliar spray of growth promoters on weed dynamics and growth attributes in annual red gram cv. APK1. The experiment was laid out in split plot design and replicated thrice. The main plot consisted of two treatments viz., mulching with crop residue and no mulch. Foliar spray of micronutrient mixture, NAA at 40 ppm, Salicylic acid at 100 ppm, Brassinolide at 0.1 ppm, Triacontanol at 500 ppm and no spray were assigned to sub plot. The results showed that the main plot treatment of mulching with crop residue reduced the DMP of grasses, sedges and BLW weeds significantly. It has also recorded higher weed control efficiency at 40 and 60 DAS. Among the sub plot treatments, foliar application of growth promoter NAA at 40 ppm recorded lower DMP of weeds regardless of their characters and recorded higher weed control efficiency at 40 and 60 DAS. Greater increase in growth attributes viz., plant height, number of branches plant^{-1} and plant DMP was observed in the main plot treatment of mulching with crop residue. Under sub plot, significant increase in all the growth attributes was noticed in foliar spray of NAA at 40 ppm irrespective of stages.

Key words: Annual redgram, Growth promoters, mulching, weed DMP, growth attributes.

Pulses are important constituents of Indian diet. They are ideal source of protein, alternative to animal protein and also cheap source of protein especially to the poorer and thereby, described as poor man's meat. Moreover, pulses are the major source to meet the protein requirement of the vegetarians. Pulses also play vital role in replenishing soil fertility status due to biological fixation of atmospheric nitrogen with help of its root nodules. Among the pulses, pigeon pea is one of the major pulse, which is cultivated in larger areas than other pulses in India.Redgram (Pigeon pea) occupies an area of around 3.90 million hectares in India with a production of 2.89 million tonnes and a productivity of 914 kg ha^{-1} (DES, 2011). In Tamil Nadu the area under redgram is about 1.40 lakh hectares with a production of 1.20 lakh tons and the productivity is 864 kg/ha, which is higher than the average national productivity, but lower than the productivity level of Uttar Pradesh (1134 kg ha^{-1}), Haryana (1145 kg/ha), Bihar (999 kg ha^{-1}), Gujarat (952 kg ha^{-1}) and Punjab (880 kg/ha).

Pulse production continues to decline in India which results in deficit in protein supply to Indian people. Hence, India ought to rely upon other countries to fulfill the protein demand in through import of pulses as per the recent report (Rajendra prasad and Sharma, 2010). Annual redgram has a total duration of 100- 105 days and posses very slow growth habit upto 50 to 65 DAS which facilitates the weeds to grow luxuriantly leading to even more than 75% yield loss and also complete crop failure under uncontrolled condition (Channappagoudar and Biradar, 2007).Weeds are controlled by many means. However, considering the current scenario of world agriculture and environment, having weed control by holistic approach would be a best option. In this context, a basic idea of suppressing weed growth by the plant growth pattern itself would be highly possible. Though the weed growth is more during early stage of crop, it will be still more in the crops which are erect with slow growing in habit. Similarly, unlike the other pulse crops which act as cover crops namely black gram and green gram, the pulse crop annual redgram is slow growing during its early growing period upto 50-65 days apart from its erect stature induces the weed growth resulting in poor growth and development of the crop.

Mulching is one of the possible ways to control weeds without using herbicides. Mulching reduced the population and dry weight of broad leaf weeds significantly as compared to grass weeds (Radwan and Hussein, 2001).

Like mulching, applying growth promoters one way or other controls the weeds without herbicides by its indirect effect as it helps in rapid crop canopy coverage which in turn control weeds by shade effect.

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Hence, foliar spray of growth promoters was also included in addition to mulching to study their effect on weeds and growth attributes in annual redgram.

Materials and Methods

Field experiment was conducted at Agricultural College and Research Institute, Madurai, Tamil Nadu during rabi 2009-2010 to study the effect of foliar spray of mulching and growth promoters on weeds and their influence on growth attributes of annual redgram. The soil of the experimental field was well drained clay loam with organic carbon content of 0.46 per cent and low, medium and high in N (191.0 kg ha^{-1}), P_2O_5 (8.70 kg ha^{-1}) and K_20 (369.01 kg ha_{-1}) respectively. The experiment consisted of two main plot treatments viz., M_1- Organic mulch with blackgram residue @ 6 tonnes ha_{-1} and M_2 – No mulch. The foliar spray of growth promoters and micro nutrient mixture were assigned to sub plot viz., S_1 - Foliar spray of micro nutrient mixture, S_2 – NAA @ 40 ppm, S_3 - Salicylic acid @ 100 ppm, S_4 – Brassinolide @ 0.1 ppm, S_5 – Triacontanol @ 500 ppm and S_6 - No spray.

In the organic mulch treatment, black gram residues were cut into small pieces and applied at the rate of six tonnes ha_{-1} on 15 days after germination in between the crop rows after thinning.

The foliar spray of micronutrient mixture as well as growth promoters were done on 15, 30, 45 and 60 DAS in the corresponding treatments. Micro nutrient mixture contains various nutrients at different concentration ($FeSO_4$ -0.5%**,** $MgSO_4$-0.5% and $ZnSO_4$ -0.5%).

With regard to observations on weeds, weed dry weight was recorded on 40 and 60DAS and expressed in kg ha_{-1}. Weed control efficiency (WCE) was calculated based on weed dry weight as per the procedure given by Mani *et al.* (1973) and expressed in percentage. All growth parameters viz., plant height, No. of branches $plant_{-1}$ and DMP were recorded at different stages of crop growth and harvest.

Results and Discussion

Effect on weeds

Effect of mulching on Weed DMP

Mulching (M_1) significantly reduced the DMP of grasses, sedges and broad leaved weeds BLW at 40 and 60 DAS (Tables 1 & 2) . Hindrance of resources like light and aeration by the crop residue mulch could have reduced the weed growth and hence low weed DMP besides killing of germinating weeds by increased soil temperature caused by

Table 1. Effect of mulching and foliar spray of growth promoters on DMP of grasses, sedges and BLW weeds g m_{-2} on 40 DAS in redgram

Treatment	Grass			Sedges			BLW		
Foliar spray	M_1-Mulch	M_2-No mulch	Mean	M_1-Mulch	M_2-No mulch	Mean	M_1-Mulch	M_2-No mulch	Mean
S_1-Micro nutrient mixture	0.737	1.161	0.949	0.738	1.143	0.940	0.740	1.131	0.935
	(3.46)	(12.49)	(7.97)	(3.47)	(11.90)	(7.68)	(3.49)	(11.53)	(7.51)
S_2-NAA@ 40 ppm	0.691	1.106	0.899	0.645	1.100	0.872	0.695	1.086	0.890
	(2.91)	(10.75)	(6.83)	(2.41)	(10.59)	(6.50)	(2.95)	(10.19)	(6.57)
S_3-Salicylic acid@100ppm	0.783	1.186	0.985	0.801	1.171	0.986	0.776	1.154	0.965
	(4.07)	(13.41)	(8.74)	(4.33)	(12.88)	(8.61)	(3.97)	(12.31)	(8.14)
S_4-Brassinolide@0.1 ppm	0.716	1.152	0.934	0.726	1.147	0.936	0.753	1.138	0.945
	(3.201)	(12.20)	(7.70)	(3.32)	(12.02)	(7.67)	(3.66)	(11.74)	(7.70)
S_5-Tricontanol@500ppm	0.742	1.196	0.969	0.795	1.186	0.990	0.776	1.174	0.975
	(3.51)	(13.70)	(8.61)	(4.24)	(13.33)	(8.78)	(3.97)	(12.93)	(8.45)
S_6-No spray	0.857	1.263	1.060	0.876	1.262	1.069	0.890	1.264	1.077
	(5.20)	(16.31)	(10.76)	(5.52)	(16.29)	(10.91)	(5.75)	(16.34)	(11.05)
Mean	0.754	1.177		0.764	1.168		0.772	1.158	
	(3.72)	(13.14)		(3.88)	(12.84)		(3.97)	(12.51)	
	SEd	CD(P= 0.05)		SEd	CD(P= 0.05)		SEd	CD(P= 0.05)	
M	0.008	0.037		0.009	0.038		0.007	0.036	
S	0.011	0.022		0.012	0.024		0.10	0.021	
MxS	0.016	NS		0.017	NS		0.015	NS	
SxM	0.015	NS		0.016	NS		0.014	NS	

Data in parenthesis are original value. Others are log(x+2) transformed values

high concentration of CO_2 under mulching than control without mulching. Zammurad iqbal Ahmed *et al*. (2007) reported that wheat straw mulching had significant effect on weed suppression in wheat. The DMP of weeds was higher under no mulch (M_2) regardless of morphology characteristics of weeds. Prevailing of conducive conditions to the germinating weeds particularly availability of resources like light and aeration without any obstruction under no mulch might be the reason why there were higher weed growth which resulted in more weed DMP at 40 and 60 DAS (Table 1 & 2). This result is in line with Tamana Bakhtl *et al*. (2009) who reported lesser weed density with mulching using newspaper in pea. In accordance with the same, the low density of weeds in the mulched plot could have reduced the dry weight of the weeds.

Effect of foliar spray of growth promoters on Weed DMP

Regarding foliar spray treatments, foliar spray of NAA at 40 PPM (S_2) registered lesser weed DMP

Table 2. Effect of mulching and foliar spray of growth promoters on DMP of grasses, sedges and BLW weeds (g.m^{-2}) on 60 DAS in redgram.

Treatment	Grasses			Sedges			BLW		
Foliar spray	M_1-Mulch	M_2-No mulch	Mean	M_1-Mulch	M_2-No mulch	Mean	M_1-Mulch	M_2-No mulch	Mean
S_1-Micronutrient mixture	0.967	1.417	1.192	0.989	1.433	1.211	0.963	1.410	1.187
	(7.28)	(24.13)	(15.70)	(7.76)	(25.13)	(16.45)	(7.52)	(24.63)	(16.07)
S_2-NAA@ 40 ppm	0.894	1.368	1.131	0.942	1.380	1.161	0.907	1.361	1.134
	(5.84)	(21.33)	(13.59)	(6.75)	(21.98)	(14.37)	(6.30)	(21.66)	(13.98)
S_3-Salicylic acid@100ppm	1.014	1.437	1.225	1.077	1.456	1.267	1.007	1.435	1.221
	(8.34)	(25.43)	(16.88)	(9.96)	(26.70)	(18.33)	(9.15)	(26.06)	(17.61)
S_4-Brassinolide@0.1 ppm	0.970	1.426	1.198	0.994	1.437	1.216	0.979	1.418	1.198
	(7.34)	(24.66)	(16.00)	(7.88)	(25.37)	(16.62)	(7.61)	(25.01)	(16.31)
S_5-Tricontanol@500ppm	1.016	1.451	1.233	1.033	1.482	1.258	1.008	1.457	1.232
	(8.39)	(26.23)	(17.31)	(8.81)	(28.33)	(18.57)	(8.60)	(27.28)	(17.94)
S_6-No spray	1.111	1.517	1.314	1.161	1.551	1.356	1.142	1.552	1.347
	(10.91)	(30.90)	(20.90)	(12.48)	(33.53)	(23.01)	(11.69)	(32.21)	(21.95)
Mean	0.995	1.436		1.033	1.457		1.001	1.439	
	(8.01)	(25.45)		(8.94)	(26.84)		(8.48)	(26.14)	
	SEd	CD(P= 0.05)		SEd	CD(P= 0.05)		SEd	CD(P= 0.05))	
M	0.010	0.044		0.008	0.036		0.007	0.031	
S	0.012	0.026		0.011	0.024		0.010	0.022	
MxS	0.019	NS		0.017	0.045		0.016	NS	
SxM	0.017	NS		0.016	0.035		0.015	NS	

Data in parenthesis are original value. Others are log(x+2) transformed values

of grasses, sedges and BLW (6.83, 14.37 and 6.57 g m^{-2} at 40 DAS and 13.59, 6.50 and 13.98 g m^{-2} at 60 DAS, respectively) over rest of the treatments (Table 1 & 2). Rapid canopy coverage of plants with foliar spray of growth promoter NAA at 40 PPM could have suppressed the weed growth through shade effect during the critical crop weed competition period particularly at early stage of crop growth. Though there are other growth promoters given as foliar spray, NAA at 40 PPM had much impact in influencing the growth of redgram as it could have more suitability specific to redgram. Shinde and Jadhav (1995) reported that foliar application of NAA at 50 ppm increased the harvest index by seven per

Table 3. Effect of mulching and foliar spray of growth promoters on weed control efficiency based on DMP at 40 and 60 DAS in red gram

Treatment	40 DAS			60 DAS		
	Mulch	No mulch		Mulch	No mulch	
Foliar spray	M_1	M_2	Mean	M_1	M_2	Mean
S_1-Micro nutrient mixture	79	27	53	76	25	51
S_2-NAA@ 40 ppm	83	36	59	80	34	57
S_3-Salicylic acid@100ppm	75	21	48	72	21	47
S_4-Brassinolide@0.1 ppm	79	27	53	76	24	50
S_5-Tricontanol@500ppm	76	19	47	73	17	45
S_6-No spray	-	-	-	-	-	-
Mean	76	26	-	75	24	

cent and DMP in red gram. Kadam *et al.* (2008) reported that NAA at 30 ppm concentrate was found to be more effective in increasing the number of branches, total dry weight and chlorophyll content in black gram. With regard to crop canopy coverage in suppression of weed growth, Dhiman Mukherjee (2007) opined that canopy spread reduced weed density and DMP in chick pea. The foliar spray of micronutrient mixture ($S_{1)}$ was found to be the next best treatment in reducing the weed density at 40 and 60 DAS in redgram (Table 1 & 2). The enhanced growth of plants next to NAA could have suppressed the weed density by providing shade effect. Gupta and Vyas (1994) observed that dry weight of soybean was increased due to application of zinc, iron and molybdenum. Iron, zinc and molybdenum are the metallic compounds of one or more enzymes which are involved in various physiological functions and there by increased the LAI, CGR and RGR leading to the development and productivity of plant.

Among the sub plot treatments, the plants under control (no spray) (S_6) recorded higher weed DMP owing to lesser crop canopy in this treatment wherein the DMP of grasses, sedges and BLW were 10.76, 10.91 and 11.05 g m^{-2} at 40 DAS and 20.90, 23.01 and 21.95 g m^{-2} at 60 DAS, respectively (Table 1 & 2). This is in corroboration with Talnikar *et al*. (2008) who reported that piegonpea gets heavily infested with weeds due to slow early growth of crop. The critical period is during the first eight weeks after sowing. As the plants in this treatment, were neither given growth promoters nor micronutrient mixture as foliar spray resulted in insufficient canopy coverage due to slow growth. This might be the reason for more dry weight of weeds in this treatment.

Table 4. Effect of mulching and foliar spray of growth promoters on plant height (cm) and no. of branches plant^{-1} in red gram at harvest

Treatment	Plant height (cm)			No. of branches plant^{-1}		
Foliar spray	M_1-mulch	M_2-No mulch	Mean	M_1-Mulch	M_2-No mulch	Mean
S_1-Micronutrient mixture	111.1	90.9	101.0	20.12	14.89	17.50
S_2-NAA@ 40 ppm	120.8	99.5	110.2	23.31	16.57	19.94
S_3-Salicylic acid@100ppm	102.5	85.0	93.8	18.45	13.45	15.95
S_4-Brassinolide@0.1 ppm	111.9	90.8	101.3	20.14	14.88	17.51
S_5-Tricontanol@500ppm	101.9	83.5	92.7	18.56	13.46	16.01
S_6-No spray	100.8	62.2	81.0	17.01	11.34	14.17
Mean	108.2	85.3		19.6	14.1	
	SEd	CD (P=0.05)		SEd	CD (P= 0.05)	
M	2.5	11.1		0.43	1.84	
S	3.5	7.4		0.59	1.24	
MxS	5.3	NS		0.88	NS	
SxM	5.06	NS		0.84	NS	

Combined effect of mulching and foliar spray of growth promoters on weed DMP

The interaction effect among mulching and foliar spray of growth promoters was significant only on DMP of sedges at 60 DAS (Table 2). As such, combined effect of organic mulch with foliar spray of NAA @ 40 ppm (M_1 S_2) reduced the DMP of sedge weeds significantly (6.75 g m^{-2} at 60 DAS).Though there were growth of BLW, grasses and sedges in the experimental field, occurrence of more no. of species with varying in growth habit under BLW and grasses might have reduced the combined effect of mulching and NAA foliar spray in controlling the BLW and grasses than sedges which were found to be not more than two species. The next lowest DMP of sedge weeds was observed in organic mulch with foliar spray of micro nutrient mixture (M_1S_1) which registered the sedge weed DMP of 7.76 g m^{-2} at 60 DAS.

Effect of mulching and foliar spray of growth promoters on weed control efficiency

Organic mulching (M_1) recorded higher weed control efficiency of 76 and 75 per cent at 40 and 60 DAS, respectively (Table 3). The treatment without mulch (M_2) recorded the least weed control efficiency of 26 and 24 per cent at 40 and 60 DAS, respectively (Table 3). Regarding foliar spray of growth promoters NAA @ 40 ppm (S_2) recorded the highest weed control efficiency of 59 and 57 per cent at 40 and 60 DAS, respectively (Table 3).

The combined effect of organic mulch and foliar spray of growth promoters NAA @ 40 ppm (M_1S_2) registered higher weed control efficiency of 80 and 83 per cent at 40 and 60 DAS, respectively (Table 3). Substantial reduction in DMP of grasses and BLW at 40 and 60 DAS and sedges at 60 DAS in these treatments would have increased the weed control efficiency. This was followed by micronutrient mixture (S_1) and brassinolide at 0.1 ppm (S_4) at 40 and 60 DAS

Table 5. Effect of mulching and foliar spray of growth promoters on DMP (kg ha^{-1}) of red gram at 40 DAS, 60 DAS and at harvest stage

Treatment	40 DAS			60 DAS			HARVEST		
Foliar spray	M_1-Mulch	M_2-No mulch	Mean	M_1-Mulch	M_2-No mulch	Mean	M_1-Mulch	M_2-No mulch	Mean
S_1-Micronutrient mixture	1919	1227	1573	6333	4244	5289	8565	6363	7464
S_2-NAA@ 40 ppm	2184	1430	1807	6786	4680	5733	9118	6883	8001
S_3-Salicylic acid@100ppm	1653	1083	1368	6196	4126	5161	8270	6152	7211
S_4-Brassinolide@0.1 ppm	1891	1201	1546	6289	4270	5280	8455	6272	7364
S_5-Tricontanol@500ppm	1697	1040	1369	6240	4083	5162	8230	6015	7123
S_6-No spray	1499	820	1160	6042	3756	4899	7980	4098	6039
Mean	1807	1134	1470	6314	4193	5254	8436	5964	7200
	SEd	CD (P = 0.05)		SEd	CD (P= 0.05)		SEd	CD (P= 0.05)	
M	35.1	150		167	720		29	125	
S	53.0	110		153	319		38	79	
Mxs	76.8	NS		259	NS		57	NS	
Sxm	74.9	NS		216	NS		53	NS	

Effect on crop

Effect of mulches on growth attributes

Application of black gram residues as organic mulch (M_1) significantly increased the plant height (108.2 cm at harvest), number of branches (19.60 plant^{-1} at harvest) and DMP (1807, 6314 and 8436 kg ha^{-1} at 40DAS, 60DAS and at harvest stage respectively), which were 35.2, 40.7 and 41.4 per cent increase over no mulch (M_2) at harvest (Table 4&5).

The black gram residues in organic mulch could have helped in increasing the conservation of soil

moisture and uptake of nutrients, which might have reflected in increasing the growth attributes. This was in agreement with the findings of Ossom and Matsenjwa (2007) in dry bean. Organic mulching would also increase microbial activity and thus the soil microbial population. The increased microbial activity would have also increased the mineralization of nutrients and thereby more uptake of nutrients. This result is in line with the findings of Matt sheriff *et al. (*2007) in legumes.

Effect of foliar spray of growth promoters on growth attributes

The foliar spray of growth promoters significantly influenced the plant height. Foliar spray of NAA @ 40 ppm (S_2) recorded the taller plants of 110.2 cm at harvest followed by the foliar spray of micro nutrient mixture (S_1) which recorded 101.0 cm at harvest (Table 4&5). Similar trend was also recorded in no. of branches plant^{-1} and DMP at harvest (Table 4&5).Application of NAA is known to increase the activation of cell division and cell elongation on the axillary buds by enhancing cytokinins synthesis. This would have increased the plant height and number of branches plant^{-1} as reported by Gupta and Gupta (2000). Ganapathy *et al.* (2008) reported similar effect due to foliar application of NAA in black gram. The increase in the no. of branches coupled with leaf area might have enhanced the synthesis of carbohydrate and provided sufficient sources for higher DMP.

Based on the investigation, it could be concluded that mulching with crop residue is the effective measure of controlling DMP of BLW, grasses and sedges at 60 DAS in annual redgram. Also, foliar spray of NAA @ 40 ppm is the best measure of checking the DMP of weeds irrespective of their morphological characteristics at 40 DAS in annual redgram. When both these two treatments combined together, the sedge weed DMP is controlled effectively at 60 DAS. With regard to growth attributes, either mulching with crop residue (or) foliar spray of NAA @ 40 ppm is the viable strategy to achieve increased plant height, no. of branches plant^{-1} and plant DMP in annual redgram.

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