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Weed Dynamics and Yield of Chickpea (*Cicer arietinum* L.) as Influenced by Pre and Post-Emergence Herbicides

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A B S T R A C T

A field experiment entitled "Efficacy of pre and post-emergence herbicides on growth and yield of chickpea (*Cicer arietinum* L.)" was conducted at Agricultural Research Station, Mandor, Jodhpur during *rabi* season of 2016-17. Field experiment was laid out in randomized block design (RBD) with sixteen treatments and replicated thrice. Sixteen treatments were tested among that two doses of each herbicides *i.e.* pendimethalin (0.40 and 0.60 kg *a.i.*/ha), oxyfluorfen (100 and 200 g *a.i.*/ha), imazethapyr (40 and 60 g *a.i.*/ha) with their combinations as pre and post-emergence including weedy check and weed free taken for computing WCE and WI, respectively. According to treatments, different doses of pendimethalin and oxyfluorfen were applied as pre-mergence (within 3 DAS), while imazethapyr was applied as post-emergence (20 DAS). Among treatments, sequential application of pre and post-emergence herbicides *i.e.* pendimethalin @ 0.60 kg *a.i.* ha^{-1} (PE) + imazethapyr @ 60 g *a.i.* ha^{-1} at 20 DAS (W_{12}) significantly reduced weed density of *Chenopodium murale* L., *Chenopodium album* L. and *Rumex dentatus* L. at 30, 60, 90 DAS and at harvest, that improved the seed yield of chickpea, but it was equally effective with treatment had received pendimethalin @ 0.60 kg *a.i.* ha^{-1} (PE) + imazethapyr @ 40 g *a.i.* ha^{-1} at 20 DAS (W_{11}) as pre and post-emergence combination. Although, weed free recorded higher seed yield and showed significant superiority over rest of the weed management treatments, but it was statistically at par with W_{12} and W_{11}.

Introduction

Chickpea is the third most important pulse crop in the world after french bean and field peas. India alone has nearly 52.5 per cent of the world acreage and production of chickpea. It is grown on acreage of 8.84 million hectare and producing 8.32 million tonnes with productivity of 942 kg ha^{-1} during 2016-17 in India. Among states, Madhya Pradesh shared around 40 per cent in total production followed by Uttar Pradesh and Rajasthan contributing only 16 and 14 per cent, respectively. In Rajasthan, chickpea is successfully cultivated in arid and semi-arid districts and occupied at second rank in respect of area (1.26 mha) with low productivity (725 kg ha^{-1}) (Anonymous, 2016). Chickpea is short stature crop with slow initial growth and therefore, heavily infested with wide spectrum of weeds. The early emergence and fast growth of the weeds lead to severe crop-weed competition for light, moisture, nutrients and space, which culminates in heavy reduction in growth and yield of chickpea and lessens the profitability (Chopra *et al*., 2003). About 40-45% reduction in yield of chickpea due to severe infestation of weeds is estimated. If proper control measures are not taken, then the loss in terms of yield may increase up to 75 per cent in chickpea (Chaudhary *et al*., 2005). The initial 60 days period considered to critical for weed crop competition in chickpea (Singh and Singh 2000), but continuously facing of the scarcity of labour and increase in labour cost, manual weed control has become a difficult task. Suitable herbicide for effective control of mixed weed flora is required for better adoption in chickpea. Introduction of herbicides has made it possible to control a wide spectrum of weeds in pulses effectively at a remunerative cost. Many research workers from the various parts of the country has been reported that the application of pendimethalin as pre-emergence at 1.0 kg ha^{-1} (Singh and Jain, 2017) and oxyfluorfen (80 g ha^{-1}) as weed control treatment (Patel *et al.,* 2006) provided effective control of annual broad leaved and grassy weeds in chickpea field at an early stages. However, later flushes of weeds can only be control by application of imazethapyr as post-emergence (Rathod *et al.,* 2017). Keeping in view these facts, the present investigation was undertaken to test the performance of pre and post-emergence herbicides either alone or combination with other weed management practices for providing effective weed control in chickpea.

Materials and Methods

Experimental site

The experiment was conducted at Agricultural Research Station, Mandor, Jodhpur during *rabi* season of 2016-17. Geographically, it is located between 26° 15' N to 26° 45' North latitude and 73° 00' E to latitude 73° 29' East longitude at an altitude of 231 meter above mean sea level. The soil was loamy sand in texture, slightly alkaline in reaction (pH 8.2), low in organic carbon (0.13%) and available nitrogen (174 kg ha^{-1}), whereas medium in phosphorus (22.2 kg P_2O_5 ha^{-1}) and available potassium (325 kg K_2O ha^{-1}). The mean daily maximum and minimum temperature fluctuated between 21.8 to 39.8^0 C and 8.8 to 22.9^0 C, respectively during the crop growing season.

Experimental treatments

The experiment was laid out in randomized block design (RBD) with sixteen weed control treatments, viz., W_1-Weedy Check, W_2-Weed free, W_3-Pendimethalin @ 0.40 kg *a.i.*/ha (PE), W_4-Pendimethalin @ 0.60 kg *a.i.*/ha (PE), W_5- Oxyfluorfen @ 100 g *a.i.*/ha (PE), W_6-Oxyfluorfen @ 200 g *a.i.*/ha (PE), W_7-Imazethapyr @ 40 g *a.i.*/ha at 20 DAS, W_8-Imazethapyr @ 60 g *a.i.*/ha at 20 DAS, W_9-Pendimethalin @ 0.40 kg *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS, W_{10}-Pendimethalin @ 0.40 kg *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS, W_{11}-Pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS, W_{12}-Pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS, W_{13}-Oxyfluorfen @ 100 g *a.i.*/ha (PE + imazethapyr @ 40 g *a.i.*/ha at 20 DAS, W_{14}-Oxyfluorfen @ 100 g *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS, W_{15}-Oxyfluorfen @ 200 g *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS and W_{16}-Oxyfluorfen @ 200 g *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS. As per treatments, pre-emergence application of pendimethalin and oxyfluorfen were applied within three days of sowing, while post-emergence application of imazethapyr was applied at 20 DAS. These herbicides were sprayed with knapsack sprayer using flat fan nozzle in about 600 litres of water per hectare. A basal dose of 20 kg N and 40 kg P_2O_5 ha^{-1} were drilled uniformly before sowing through urea and diammonium phosphate, respectively in individual plot at the depth of 7 to 8 cm below the seed. After harvesting of crop, cleaned seeds were weighed to record seed yield per plot and then it converted in kg/ha. All the data were statistically analyzed to draw a valid conclusion.

Results and Discussion

Effect of weed management treatments on weed dynamics

Relative composition of different weeds

Data pertaining to relative composition of different weed flora as affected by different weed management practices (Table 1). It was observed that higher relative distribution of *Chenopodium murale* L. was reported among three weed flora followed by *Chenopodium album* L. and *Rumex dentatus* L. under particular set of the treatments.

The relative density of *Rumex dentatus* L. was higher under pre and post-emergence combination of pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS (W_{12}), whereas *Chenopodium murale* L. was higher under weedy check.

While relative density of *Chenopodium album* L. was higher under post-emergence application of imazethapyr with its two doses *i.e.* 60 and 40 g *a.i.*/ha at all growth stages of crops except 30 DAS, where it was maximum under oxyfluorfen @ 100 g *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS. However, mean relative composition in terms of percentage may be more in context to respective weed flora under particular treatment, but their densities were recorded lower under W_{11} and W_{12}.

Density of *Chenopodium murale* (No. m^{-2})

Chenopodium murale was one of the dominant weeds of the experimental plot (Table 2). The data revealed that density of *Chenopodium murale* significantly increased as the advancement of crop up to 60 DAS and there after decreased. It was found that combined application of pre and post-emergence herbicides *i.e.* pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS (W_{12}) recorded significantly lower weed density of *Chenopodium murale,* but it showed statistically at par with the treatment had received pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS (W_{11}) at all growth stages of crop. Due to season long weeding under weed free treatment (W_2) recorded none of the weed count and showed equally effective as W_{12} and W_{11} treatments. Similar results were reported by Kalyani (2011). Among alone application of herbicides, pre-emergence application of oxyfluorfen (100 and 200 g *a.i.* ha^{-1}) proved inferior in this regard, whereas weedy check recorded higher density of *Chenopodium murale* at all growth stages of crop during experimentation. It was also found that when all herbicides integrated with imazethapyr reduced the density of *Chenopodium murale* compared to their sole application. Although, application of higher doses of pendimethalin, oxyfluorfen and imazethapyr found significantly superior over its lower doses (Dewangan *et al.,* 2016).

Chenopodium album (No. m^{-2})

Chenopodium album was the dominant weed of the experimental plot next to *Chenopodium murale* (Table 3). Scanning of data on density of *Chenopodium album* revealed significant reduction in its population by different weed management treatments.

Table.1 Relative density of *Chenopodium album*, *Chenopodium murale* and *Rumex dentatus* as influenced various by weed management treatments

Treatments	Relative composition of weeds (%)											
	30 DAS			60 DAS			90 DAS			At harvest		
	A	B	C	A	B	C	A	B	C	A	B	C
W_1	20.38	75.79	3.83	17.89	77.85	4.26	23.86	71.72	4.42	23.16	72.88	3.95
W_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
W_3	27.81	59.76	12.43	26.60	59.61	13.79	27.66	57.45	14.89	25.81	61.29	12.90
W_4	25.66	61.18	13.16	26.67	58.33	15.00	28.13	56.25	15.63	25.93	60.49	13.58
W_5	24.28	67.34	8.38	24.93	65.42	9.65	25.09	67.01	7.90	22.86	69.05	8.10
W_6	23.91	67.39	8.70	24.44	65.73	9.83	25.09	66.67	8.24	23.32	68.39	8.29
W_7	27.45	60.78	11.76	28.92	58.63	12.45	28.49	61.29	10.22	27.07	61.65	11.28
W_8	27.57	60.00	12.43	28.70	58.26	13.04	28.74	60.48	10.78	28.21	60.68	11.11
W_9	24.59	54.10	21.31	20.69	50.00	29.31	20.45	54.55	25.00	25.93	51.85	22.22
W_{10}	23.08	53.85	23.08	20.00	50.00	30.00	18.92	54.05	27.03	23.81	52.38	23.81
W_{11}	22.58	41.94	35.48	17.24	41.38	41.38	19.05	42.86	38.10	26.67	46.67	26.67
W_{12}	20.83	37.50	41.67	16.67	37.50	45.83	13.33	40.00	46.67	20.00	50.00	30.00
W_{13}	28.16	54.37	17.48	24.49	51.02	24.49	25.93	50.62	23.46	26.67	56.67	16.67
W_{14}	27.17	54.35	18.48	23.60	50.56	25.84	26.39	50.00	23.61	27.45	54.90	17.65
W_{15}	25.00	53.95	21.05	23.29	46.58	30.14	24.56	47.37	28.07	27.50	52.50	20.00
W_{16}	24.24	53.03	22.73	22.73	45.45	31.82	25.53	42.55	31.91	30.30	48.48	21.21

A-*Chenopodium album*, B- *Chenopodium murale*, C- *Rumex dentatus*

Table.2 Density of *Chenopodium murale* as influenced by various weed management treatments

Treatments	*Chenopodium murale* (No. m^{-2})			
	30 DAS	60 DAS	90 DAS	At Harvest
W_1	14.81 (224.33)	16.67 (280.00)	12.67 (162.33)	11.33 (129.00)
W_2	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W_3	5.83 (33.67)	6.36 (40.33)	5.21 (27.00)	4.39 (19.00)
W_4	5.60 (31.00)	5.93 (35.00)	4.91 (24.00)	4.07 (16.33)
W_5	8.83 (77.67)	9.02 (81.33)	8.08 (65.00)	6.96 (48.33)
W_6	8.53 (72.33)	8.84 (78.00)	7.73 (59.33)	6.66 (44.00)
W_7	6.45 (41.33)	6.99 (48.67)	6.20 (38.00)	5.26 (27.33)
W_8	6.10 (37.00)	6.70 (44.67)	5.84 (33.67)	4.90 (23.67)
W_9	3.38 (11.00)	3.17 (9.67)	2.88 (8.00)	2.26 (4.67)
W_{10}	3.11 (9.33)	2.94 (8.33)	2.65 (6.67)	2.02 (3.67)
W_{11}	2.18 (4.33)	2.11 (4.00)	1.86 (3.00)	1.68 (2.33)
W_{12}	1.86 (3.00)	1.86 (3.00)	1.56 (2.00)	1.44 (1.67)
W_{13}	4.37 (18.67)	4.13 (16.67)	3.74 (13.67)	3.42 (11.33)
W_{14}	4.13 (16.67)	3.93 (15.00)	3.52 (12.00)	3.12 (9.33)
W_{15}	3.74 (13.67)	3.41 (11.33)	3.05 (9.00)	2.72 (7.00)
W_{16}	3.48 (11.67)	3.24 (10.00)	2.67 (6.67)	2.40 (5.33)
SEm±	0.24	0.21	0.19	0.16
C.D.(P=0.05)	0.71	0.61	0.55	0.47

Figures in parentheses are the original value

Table.3 Density of Chenopodium album as influenced by various weed management treatments

Treatments	*Chenopodium album* (No. m^{-2})			
	30 DAS	**60 DAS**	**90 DAS**	**At Harvest**
W_1	7.78 (60.33)	8.03 (64.33)	7.38 (54.00)	6.44 (41.00)
W_2	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W_3	3.99 (15.67)	4.30 (18.00)	3.67 (13.00)	2.91 (8.00)
W_4	3.65 (13.00)	4.04 (16.00)	3.53 (12.00)	2.72 (7.00)
W_5	5.31 (28.00)	5.60 (31.00)	4.98 (24.33)	4.06 (16.00)
W_6	5.09 (25.67)	5.42 (29.00)	4.77 (22.33)	3.94 (15.00)
W_7	4.36 (18.67)	4.92 (24.00)	4.26 (17.67)	3.53 (12.00)
W_8	4.16 (17.00)	4.73 (22.00)	4.06 (16.00)	3.39 (11.00)
W_9	2.32 (5.00)	2.10 (4.00)	1.84 (3.00)	1.64 (2.33)
W_{10}	2.11 (4.00)	1.93 (3.33)	1.64 (2.33)	1.44 (1.67)
W_{11}	1.68 (2.33)	1.46 (1.67)	1.34 (1.33)	1.34 (1.33)
W_{12}	1.46 (1.67)	1.34 (1.33)	1.05 (0.67)	1.05 (0.67)
W_{13}	3.17 (9.67)	2.88 (8.00)	2.72 (7.00)	2.40 (5.33)
W_{14}	2.95 (8.33)	2.72 (7.00)	2.59 (6.33)	2.26 (4.67)
W_{15}	2.58 (6.33)	2.46 (5.67)	2.24 (4.67)	2.00 (3.67)
W_{16}	2.40 (5.33)	2.33 (5.00)	2.08 (4.00)	1.93 (3.33)
SEm±	0.14	0.12	0.10	0.08
C.D.(P=0.05)	0.40	0.35	0.29	0.23

Figures in parentheses are the original value

Table.4 Density of *Rumex dentatus* as influenced by various weed management treatments

Treatments	*Rumex dentatus* (No. m^{-2})			
	30 DAS	60 DAS	90 DAS	At Harvest
W_1	3.44 (11.33)	3.97 (15.33)	3.21 (10.00)	2.72 (7.00)
W_2	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)
W_3	2.72 (7.00)	3.10 (9.33)	2.70 (7.00)	2.08 (4.00)
W_4	2.66 (6.67)	3.06 (9.00)	2.66 (6.67)	2.02 (3.67)
W_5	3.17 (9.67)	3.52 (12.00)	2.82 (7.67)	2.46 (5.67)
W_6	3.12 (9.33)	3.48 (11.67)	2.79 (7.33)	2.40 (5.33)
W_7	2.88 (8.00)	3.28 (10.33)	2.60 (6.33)	2.32 (5.00)
W_8	2.84 (7.67)	3.22 (10.00)	2.53 (6.00)	2.18 (4.33)
W_9	2.16 (4.33)	2.46 (5.67)	2.02 (3.67)	1.56 (2.00)
W_{10}	2.10 (4.00)	2.32 (5.00)	1.93 (3.33)	1.46 (1.67)
W_{11}	2.02 (3.67)	2.08 (4.00)	1.76 (2.67)	1.34 (1.33)
W_{12}	1.93 (3.33)	2.02 (3.67)	1.68 (2.33)	1.22 (1.00)
W_{13}	2.5 (6.00)	2.88 (8.00)	2.58 (6.33)	1.93 (3.33)
W_{14}	2.46 (5.67)	2.83 (7.67)	2.46 (5.67)	1.86 (3.00)
W_{15}	2.39 (5.33)	2.79 (7.33)	2.39 (5.33)	1.74 (2.67)
W_{16}	2.30 (5.00)	2.70 (7.00)	2.32 (5.00)	1.66 (2.33)
SEm±	0.08	0.09	0.07	0.05
C.D.(P=0.05)	0.23	0.26	0.20	0.14

Figures in parentheses are the original value

Table.5 Seed yield of chickpea as influenced by various weed management treatments

Treatments		Seed yield (kg ha^{-1})
W_1	Weedy	728.33
W_2	Weed free (Season long)	2327.33
W_3	Pendimethalin @ 0.40 kg *a.i.* ha^{-1} (PE)	1561.33
W_4	Pendimethalin @ 0.60 kg *a.i.* ha^{-1} (PE)	1607.33
W_5	Oxyflourfen @100 g *a.i.* ha^{-1} (PE)	1189.00
W_6	Oxyflourfen @ 200 g *a.i.* ha^{-1} (PE)	1274.67
W_7	Imazethapyr @ 40 g *a.i.* ha^{-1} at 20 DAS	1398.67
W_8	Imazethapyr @ 60 g *a.i.* ha^{-1} at 20 DAS	1489.00
W_9	Pendimethalin @ 0.40 kg *a.i.* ha^{-1} (PE) + Imazethapyr @ 40 g *a.i.* ha^{-1} at 20 DAS	1991.33
W_{10}	Pendimethalin @ 0.40 kg *a.i.* ha^{-1} (PE) + Imazethapyr @ 60 g *a.i.* ha^{-1} at 20 DAS	2077.67
W_{11}	Pendimethalin @ 0.60 kg *a.i.* ha^{-1} (PE) + Imazethapyr @ 40 g *a.i.* ha^{-1} at 20 DAS	2231.33
W_{12}	Pendimethalin @ 0.60 kg *a.i.* ha^{-1} (PE) + Imazethapyr @ 60 g *a.i.* ha^{-1} at 20 DAS	2303.33
W_{13}	Oxyflourfen @100 g *a.i.* ha^{-1} (PE) + Imazethapyr @ 40 g *a.i.* ha^{-1} at 20 DAS	1715.33
W_{14}	Oxyflourfen @100 g *a.i.* ha^{-1} (PE) + Imazethapyr @ 60 g *a.i.* ha^{-1} at 20 DAS	1749.67
W_{15}	Oxyflourfen @ 200 g *a.i.* ha^{-1} (PE) + Imazethapyr @ 40 g *a.i.* ha^{-1} at 20 DAS	1855.33
W_{16}	Oxyflourfen @ 200 g *a.i.* ha^{-1} (PE) + Imazethapyr @ 60 g *a.i.* ha^{-1} at 20 DAS	1872.67
SEm±		36.91
CD (*P*=0.05)		104.23

It was noticed that combined application of pre and post-emergence herbicides *i.e.* pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS (W_{12}) had significantly lowered density of *Chenopodium album* and showed its superiority over rest of the treatments including weedy check at all growth stages of crop. However, this treatment (W_{12}) found at par with pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS (W_{11}). These results are in the conformity with the work of Singh *et al.,* (2014). Among individual categories of herbicides and their doses, application of oxyfluorfen (100 and 200 g *a.i.* ha^{-1}) as pre-emergence showed poor in controlling weed population at all growth stages.

Rumex dentatus (No. m^{-2})

Rumex dentatus was the third major weed flora in the experimental plot (Table 4). A cursory glance of data indicated that sequential application of pre and post-emergence herbicides *i.e.* pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS (W_{12}) produced marked variation in the density of *Rumex dentatus* and recorded significantly minimum density that established its superiority over other treatments at all growth stages, though it remained at par with pre and post-emergence application of herbicides *i.e.* pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS (W_{11}). Similar results were reported by Kalyani (2011) and Poonia and Pithia (2013). Weedy check (W_1) heavily infested with weed flora of *Rumex dentatus* and recorded more in density as compared to other weed management treatments during field trial. Similarly, other treatments also recorded minimum density of the same weed in contrast to weedy check during the year of experimentation.

Effect of weed management treatments on yield of chickpea

Seed yield is an important parameter which decides the efficiency and superiority of a particular treatment over other treatments. Sequential application of pre and post-emergence herbicide *i.e.* pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS (W_{12}) and pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS (W_{11}) were recorded significantly higher seed yield (2303.33 and 2231.33 kg ha^{-1}), respectively over other weed management treatments, but these were at par with each other and also showed equally effective as weed free treatment (W_2). While lesser difference of increments between W_2, W_{12} andW_{11} treatments were noticed due to similar weed control across the crop growth period. It was might be due to lesser infestation of weeds that encourage proper translocation of photosynthesis from source to sink. Such condition may increase the seed production ratio in total produce. Similar results were also reported by Dubey *et al.,* (2018) and Kalyani (2011) (Table 5).

It is concluded that combined application of pre and post-emergence herbicides *i.e.* pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 60 g *a.i.*/ha at 20 DAS recorded lower density of weeds *viz.*, *Chenopodium murale*, *Chenopodium album* and *Rumex dentatus* and also recorded higher seed yield, but equally effective with similar combinations and lower doses herbicide *i.e.* pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS in this regards. Imazethapyr as post-emergence caused plant injury, but recover faster rate at later stages. Keeping in all views in mind, pendimethalin @ 0.60 kg *a.i.*/ha (PE) + imazethapyr @ 40 g *a.i.*/ha at 20 DAS as pre and post-emergence herbicide may be feasible and taken for further research.

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