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RESEARCH ARTICLE

Effect of herbicides against *Phalaris minor* and other weeds in wheat under middle Gujarat condition

Harsh K. Patel, V.J. Patel* and D.D. Chaudhari

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ABSTRACT

Phalaris minor Retz. now became a problematic weed of wheat in middle Gujarat condition due to its morphological similarity with wheat and continuous use of broad-spectrum herbicide. To combat this problem, an experiment was conducted during winter (*Rabi*) season of 2021-22 and 2022-23 on loamy sand soil at the farm of AICRP-Weed Management, Anand Agricultural University (Gujarat). The study aimed to find out instead of studied effect of herbicides against *P. minor* and other weeds in wheat. Results revealed that pre-mix (PM) application of clodinafop-propargyl 15% + metsulfuron-methyl 1% WP (PM) 60 + 4 g/ha as post-emergence (PoE) or sulfosulfuron 75% + metsulfuron-methyl 5% WG (PM) 30 + 2 g/ha PoE and sequential application of pendimethalin 30% EC 500 g/ha as pre-emergence (PE) *fb* clodinafop-propargyl 15% WP 60 g/ha PoE or sulfosulfuron 75% WP 30 g/ha PoE or hand weeding at 20 and 40 days after sowing (DAS) provide effective control of *P. minor* with broad-spectrum weed control resulted in higher grain yield and benefit-cost ratio.

Keywords: Crop yield, Herbicides, *Phalaris minor*, Pre-mix, Weed control efficiency, Wheat

INTRODUCTION

Wheat (*Triticum aestivum* L.), a member of the Poaceae family, is a staple food and the primary cereal crop grown worldwide. Wheat plays a significant role as a key *Rabi* crop in India and is an essential cereal and staple food, ranking second in importance only after rice. The major wheat growing states in India are Uttar Pradesh, Madhya Pradesh, Punjab, Haryana, Bihar, Rajasthan and Gujarat. Wheat cultivation in Gujarat was 10.46 lakh hectares in 2021-22, with a production of 33.24 lakh tonnes and average productivity of 3179 kg/ha (Anon., 2021). Weeds pose a substantial threat to agricultural production, impacting both crop yields and biodiversity. These invasive plants, if not managed effectively, can lead to significant crop losses and environmental degradation. Wheat crop is generally infested with both grassy and broad-leaf weeds depending upon environmental conditions like humidity, temperature and moisture availability, type of soil, cultural practices, varieties used and crop rotation adopted.

Phalaris minor Retz. is an annual grassy weed (family: Poaceae), locally, it is called Dumbisitti, Gullidanda, Sitti, Kanki and Mandusi. It is a monocot, self-pollinated, C_3 weed (2n = 28), associated with wheat crop (Chhokar *et al*. 2018). During the initial growth stages, plants of *P. minor* are morphologically similar to wheat plants and thus, escape during hand weeding which is done mainly in between the crop rows. In wheat, chemical weed control is a preferred practice due to the scarce and costly labour as well as the lesser feasibility of mechanical or manual weeding to manage such a mimic weed. Combinations of herbicides are preferable since they require lower dosage/ rates and leave less residue in the soil, which will biodegrade in a shorter time, improve the succeeding crop safety and smart strategy for controlling both monocot and dicot weeds in wheat fields. It improved the efficiency of the herbicide and increased activity on the targeted weed species while lowering crop toxicity. The problem of *P. minor* is increasing year after year which leads to huge reduction in wheat yield particularly in wheat growing area of Ahmedabad, Kheda, Anand, Gandhinagar and Sabarkantha district of Gujarat state (Anon. 2011). Looking to this an experiment was planned to study the effect of herbicides against *P. minor* and other weeds in wheat (*Triticum aestivum* L.) under middle Gujarat condition.

Department of Agronomy, BACA, Anand Agricultural University, Anand, Gujarat, India

* Corresponding author email: avjpatel28@aau.in

MATERIALS AND METHODS

Field experiment was carried out during winter (*Rabi*) season of the year 2021-22 and 2022-23 on loamy sand soil at the farm of AICRP-Weed Management, B. A. College of Agriculture, Anand Agricultural University, Anand (Gujarat). The experiment was laid out in randomized block design with three replications and twelve treatments, *viz*. pendimethalin 30% EC 500 g/ha PE *fb* clodinafop-propargyl 15% WP 60 g/ha PoE, flumioxazin 50% SC 125 g/ha PE *fb* clodinafop-propargyl 15% WP 60 g/ha PoE, pyroxasulfone 85% WG 127.5 g/ha PE *fb* clodinafop-propargyl 15% WP 60 g/ha PoE, pendimethalin 30% EC 500 g/ha PE *fb* sulfosulfuron 75% WP 30 g/ha PoE, pendimethalin 30% EC + metribuzin 70% WP (TM) 500 + 140 g/ha PE, clodinafop-propargyl 15% + metsulfuron-methyl 1% WP (PM) 60 + 4 g/ha PoE, sulfosulfuron 75% + metsulfuron-methyl 5% WG (PM) 30 + 2 g/ha PoE, mesosulfuron-methyl 3% + iodosulfuron-methyl sodium 0.6% WDG (PM) 12 + 2.4 g/ha PoE, metribuzin 42% + clodinafop-propargyl 12% WG (PM) 140 + 40 g/ha PoE, metribuzin 42% + clodinafop-propargyl 12% WG (PM) 210 + 60 g/ha PoE, hand weeding at 20 and 40 DAS and un-weeded check. Pre-emergence and post-emergence herbicides were applied as per the treatments using a knapsack sprayer equipped with a flat fan nozzle, using 500 liters of water per hectare. The recommended seed rate of 120 kg/ha for wheat cv. "*Gujarat Wheat 451*" was sown keeping the distance of 22.5 cm row spacing by manually in previously open furrows with the help of kudali. Later the seeds were covered manually. The recommended dose of nitrogen and phosphorus (120-60 kg N and P/ha) was applied through urea and SSP, respectively. The entire dose of phosphorus and half dose of nitrogen were applied to all the plots as basal dose in furrow prior to sowing. The remaining half dose of nitrogen was applied at 30 DAS. Irrigation was given after sowing of wheat and pre-emergence herbicides were applied after next day of first irrigation and post-emergence herbicides were applied at 30 DAS. The phytotoxicity of herbicides was noted at 10 and 20 days after herbicide application (DAHA), using a phytotoxicity scoring chart on a scale from 0 to 10 in each plot. At the maturity of crop, border lines were harvested first and were removed from the experimental area. Then the net plot area was harvested separately. Weed parameters taken randomly from 0.25 m^2 quadrant from net plot area from each treatment and converted into m^2 area. The monocot weeds including *P. minor,* monocot and dicot weeds were separated and counted separately from each plot at 25, 50 DAS and at harvest. Data on various observations recorded during the experimental period was statistically analysed as per the standard procedure and weed data were transformed by square root transformation ($\sqrt{(x+1)}$) and transformed data were subjected to ANOVA analysis (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Weed flora

Major weed flora observed on un-weeded check plot comprised of *P. minor, Setaria tomentosa, Dactyloctenium aegyptium, Digitaria sanguinalis* and *Eleusine indica* among monocot weeds, while *Chenopodium album, Chenopodium murale, Digera arvensis* and *Melilotus indica* among dicot weeds in loamy sand soil during both years of the experimentation.

Effect on weeds

Results indicated that weed control treatment showed significantly lower density and dry weight of *P. minor*, monocot and dicot weeds recorded at 25 DAS in twice hand weeding at 20 and 40 DAS and treatment received pre-emergence herbicides as compared to treatment with post-emergence herbicides and un-weeded check (**Table 1**). Among all the pre-emergence treatments, application of pendimethalin 30% EC 500 g/ha, flumioxazin 50% SC 125 g/ha and pyroxasulfone 85% WG 127.5 g/ha recorded significantly lower density and dry biomass of *P. minor* as compared to un-weeded check at 25 DAS. Similarly, Kaur *et al*. (2019) also found that pre-emergence application of pyroxasulfone at 127.5 g/ha recorded effective control of *P. minor* in wheat. However, application of metribuzin 42% + clodinafop-propargyl 12% WG (PM) 210 + 60 g/ha PoE provided 100% control of *P. minor* at 50 DAS but it was showed phytotoxic effect on wheat crop. Application of either flumioxazin 50% SC 125 g/ha PE *fb* clodinafop-propargyl 15% WP 60 g/ha PoE or pyroxasulfone 85% WG 127.5 g/ha PE *fb* clodinafop-propargyl 15% WP 60 g/ha PoE or pendimethalin 30% EC 500 g/ha PE *fb* sulfosulfuron 75% WP 30 g/ha PoE or pendimethalin 30% EC 500 g/ha PE *fb* clodinafop-propargyl 15% WP 60 g/ha PoE or clodinafop-propargyl 15% + metsulfuron-methyl 1% WP (PM) 60 + 4 g/ha PoE effectively reduced the density and dry biomass of *P. minor* at 50 DAS. Among herbicidal treatments, pendimethalin 30% EC + metribuzin 70% WP (TM) 500 + 140 g/ha PE found less effective against *P. minor* but effectively reduced the density and dry biomass of dicot weeds at 50 DAS. Sequential application of clodinafop-propargyl 15% WP 60 g/ha PoE provided effective control of monocot weed. The application of premix herbicides such a metribuzin 42% + clodinafop-propargyl 12%

WG 210 + 60 g/ha PoE, mesosulfuron-methyl 3% + iodosulfuron-methyl sodium 0.6% WDG 12 + 2.4 g/ha PoE, clodinafop-propargyl 15% + metsulfuron-methyl 1% WP 60 + 4 g/ha PoE and sulfosulfuron 75% + metsulfuron-methyl 5% WG 30 + 2 g/ha PoE effectively reduced the density and dry biomass of monocot and dicot weeds at 50 DAS than other treatments. Similar results were also reported by Sharma *et al.* (2003), Bharat and Kachroo (2007) and Tomar and Tomar (2014).

In relation to weed control efficiency (WCE), sequential application of pendimethalin 30 % EC 500 g/ha PE *fb* either clodinafop-propargyl 15% WP 60 g/ha or sulfosulfuron 75% WP 30 g/ha as well as all the treatment of premix herbicides, provided more than 89% control of *P. minor* and more than 81% monocot (including *P. minor*) and dicot weeds at 50 DAS. Pre-emergence application of pendimethalin 30% EC + metribuzin 70% WP (TM) 500 + 140 g/ha found effective against *P. minor* (94% WCE) only at 25 DAS but at 50 DAS it was failed to control the *P. minor* and recorded only 22% WCE. However, it provided more than 85% weed control efficiency of dicot weed at 50 DAS. Hand weeding twice effectively manages weeds and reduces their dry weight, resulted in higher WCE of *P. minor*, monocot and dicot weed at 50 DAS.

Phytotoxicity

Data presented in **table 2** indicated that visual phytotoxicity symptoms of chlorosis on wheat crop was observed in mesosulfuron-methyl 3% + iodosulfuron-methyl sodium 0.6% WDG (PM) at 12 + 2.4 g/ha PoE at 10 days after application but it was recovered with crop growth. However, application of metribuzin 42% + clodinafop-propargyl 12% WG (PM) PoE at both the rate i.e., 140 + 40 g/ha and 210 + 60 g/ha PoE showed chlorosis symptoms on wheat crop (3 and 4 score, respectively) at 10 days after application and even at 20 days after application phytotoxicity was observed upto 1 score. Additionally, this herbicide combination shows wilting (score 1) at 10 days after application but it recovered at 20 days after application. Combined application of metribuzin and clodinafop aggravates phytotoxic effects, leading to control of weeds but also damage the wheat crop. Results of metribuzin phytotoxic effect are in conformity with the finding of Sidhu *et al.* (2014), Sharma *et al.* (2018) and Qazizada *et al.* (2022).

Table 1. Density and dry biomass of *Palmaris minor*, monocot and dicot weeds as influenced by different weed management practices (two years pooled data)

Treatment	Weed density (no./m^2)						Weed dry biomass (g/m^2)					
	P. minor		Monocot		Dicot		*P. minor*		Monocot		Dicot	
	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS
Pendimethalin 500 g/ha PE *fb* clodinafop-propargyl 60 g/ha PoE	3.72 (14.0)	2.51 (6.2)	5.19 (26.3)	3.38 (10.5)	3.17 (10.7)	3.95 (15.2)	1.58 (1.5)	2.34 (5.00)	2.07 (3.3)	3.25 (9.7)	1.65 (2.0)	3.63 (12.4)
Flumioxazin 125 g/ha PE *fb* clodinafop-propargyl 60 g/ha PoE	4.93 (24.7)	1.74 (2.2)	6.41 (41.3)	1.74 (2.2)	2.92 (8.0)	3.96 (15.2)	2.07 (3.5)	1.79 (2.3)	2.77 (6.9)	2.24 (4.1)	1.42 (1.1)	3.22 (9.5)
Pyroxasulfone 127.5 g/ha PE *fb* clodinafop-propargyl 60 g/ha PoE	5.20 (28.7)	2.13 (4.0)	7.02 (49.7)	2.63 (6.0)	4.35 (18.7)	5.97 (35.7)	2.10 (3.8)	2.11 (3.7)	2.66 (6.5)	3.18 (9.2)	1.57 (1.5)	4.35 (18.2)
Pendimethalin 500 g/ha PE *fb* sulfosulfuron 30 g/ha PoE	3.73 (14.7)	2.41 (5.5)	5.31 (27.8)	3.48 (12.0)	3.26 (11.5)	3.94 (14.7)	1.58 (1.6)	2.35 (5.1)	2.00 (3.1)	3.23 (9.6)	1.67 (2.0)	3.62 (12.6)
Pendimethalin + metribuzin (TM) 500 + 140 g/ha PE	3.83 (14.7)	5.52 (31.3)	5.22 (26.8)	5.91 (36.3)	3.13 (9.8)	4.97 (25.3)	1.57 (1.5)	8.25 (70.5)	1.89 (2.6)	8.91 (81.2)	1.60 (1.7)	4.02 (16.1)
Clodinafop-propargyl + metsulfuron-methyl (PM) 60 + 4 g/ha PoE	9.81 (101.3)	2.74 (7.0)	13.85 (193.7)	4.32 (18.0)	7.32 (55.3)	3.20 (10.0)	4.33 (18.8)	2.61 (5.9)	6.11 (36.5)	3.68 (12.9)	3.79 (13.7)	2.15 (3.7)
Sulfosulfuron + metsulfuron-methyl (PM) 30 + 2 g/ha PoE	10.37 (110.7)	3.35 (10.7)	14.55 (212.2)	5.70 (32.0)	7.46 (56.3)	2.68 (6.7)	4.15 (16.9)	3.12 (8.8)	5.90 (34.2)	3.94 (14.9)	3.59 (12.1)	2.46 (5.1)
Mesosulfuron-methyl + iodosulfuron-methyl sodium (PM) 12 + 2.4 g/ha PoE	10.18 (108.0)	2.41 (5.0)	14.15 (200.3)	5.24 (26.7)	7.80 (63.3)	3.37 (11.3)	4.63 (21.1)	3.21 (9.9)	6.19 (37.5)	4.29 (17.6)	3.86 (14.3)	3.55 (11.8)
Metribuzin + clodinafop-propargyl (PM) 140 + 40 g/ha PoE	10.01 (105.3)	2.11 (3.7)	13.96 (196.3)	3.07 (10.3)	7.86 (63.0)	1.00 (0.0)	4.77 (22.6)	3.05 (8.5)	6.58 (42.8)	3.54 (12.1)	3.84 (14.1)	1.00 (0.0)
Metribuzin + clodinafop-propargyl (PM) 210 + 60 g/ha PoE	10.19 (108.0)	1.00 (0.0)	14.61 (214.3)	1.00 (0.0)	7.57 (57.7)	1.00 (0.0)	4.78 (23.3)	1.00 (0.0)	6.47 (41.2)	1.00 (0.0)	3.60 (12.2)	1.00 (0.0)
Hand weeding at 20 and 40 DAS	1.00 (0.0)	4.63 (21.0)	1.00 (0.0)	6.13 (37.8)	1.00 (0.0)	3.87 (14.2)	1.00 (0.0)	1.98 (3.1)	1.00 (0.0)	2.33 (4.5)	1.00 (0.0)	1.70 (1.9)
Un-weeded check	10.74 (118.7)	7.82 (64.7)	14.96 (223.7)	11.73 (143.7)	8.09 (66.7)	8.93 (79.3)	4.88 (23.5)	9.28 (87.6)	6.96 (47.7)	10.36 (111.0)	3.98 (15.2)	11.09 (123.9)
LSD (p=0.05)	2.31	1.61	1.56	1.56	2.04	1.75	0.67	1.49	0.56	2.32	0.69	1.26

*Figures in parentheses are means of original values. Data subjected to transformation $[\sqrt{(x+1)}]$

Effect on crop

Effect of different weed management practices did not exert any significant effect on plant population recorded at 15 DAS during both years of the study. Different pre-emergence herbicides did not induce any phytotoxicity. Therefore, plant populations were comparable with all herbicidal treatments, including manual weeding and weedy check treatment. Grain and straw yield of wheat (**Table 3**) was recorded significantly higher under pendimethalin 30% EC 500 g/ha PE *fb* clodinafop-propargyl 15% WP 60 g/ha PoE which was followed by clodinafop-propargyl 15% + metsulfuron-methyl 1% WP (PM) 60 + 4 g/ha PoE, sulfosulfuron 75% + metsulfuron-methyl 5% WG (PM) 30 + 2 g/ha PoE and hand weeding at 20 and 40 DAS during both years of the study. The higher yield might be due to better control of both monocot and dicot weeds including *P. minor* due to sequential and pre-mix application herbicide provided congenial conditions for better growth and development of crop which resulted in higher yield. In this line of work, Hundal and Dhillon (2018) observed that sequential application of pendimethalin 750 g/ha PE *fb* clodinafop 60 g/ha PoE provided effective broad-spectrum weed control. This reduced crop-weed competition, thereby creating congenial conditions for better growth and development, which resulted in higher grain yield of wheat. The results are in accordance with the results reported by Chaudhari *et al.* (2017), Patel *et al.* (2021) and Kumar *et al.* (2023). Further, it was observed that application of metribuzin 42% + clodinafop-propargyl 12% WG (PM) PoE at both the rate i.e., 140 + 40 g/ha and 210 + 60 g/ha PoE provided effective control of weeds,

Table 2. Weed control efficiency and phytotoxicity as influenced by different weed management practices (two years pooled data)

Treatment	Weed control efficiency (%)						Phytotoxicity scoring (0-10)			
	P. minor		Monocot weed		Dicot weed		Chlorosis (DAHA)		Wilting (DAHA)	
	25 DAS	50 DAS	25 DAS	50 DAS	25 DAS	50 DAS	10	20	10	20
Pendimethalin 500 g/ha PE *fb* clodinafop-propargyl 60 g/ha PoE	93.6	94.9	93.0	90.2	88.8	89.7	0	0	0	0
Flumioxazin 125 g/ha PE *fb* clodinafop-propargyl 60 g/ha PoE	85.7	97.5	85.5	96.1	91.4	91.7	0	0	0	0
Pyroxasulfone 127.5 g/ha PE *fb* clodinafop-propargyl 60 g/ha PoE	85.7	96.1	86.3	89.9	90.0	85.0	0	0	0	0
Pendimethalin 500 g/ha PE *fb* sulfosulfuron30 g/ha PoE	93.9	94.8	93.6	90.7	88.2	89.5	0	0	0	0
Pendimethalin + metribuzin (TM) 500 + 140 g/ha PE	94.0	22.2	94.4	26.0	89.9	85.7	0	0	0	0
Clodinafop-propargyl + metsulfuron-methyl (PM) 60 + 4 g/ha PoE	-	93.0	-	85.0	-	97.0	0	0	0	0
Sulfosulfuron + metsulfuron-methyl (PM) 30 + 2 g/ha PoE	-	89.6	-	83.9	-	95.8	0	0	0	0
Mesosulfuron-methyl + iodosulfuron-methyl sodium (PM) 12 + 2.4 g/ha PoE	-	89.4	-	81.2	-	90.3	1	0	0	0
Metribuzin + clodinafop-propargyl (PM) 140 + 40 g/ha PoE	-	90.3	-	89.2	-	100.0	3	1	1	0
Metribuzin + clodinafop-propargyl (PM) 210 + 60 g/ha PoE	-	100.0	-	100.0	-	100.0	4	1	1	0
Hand weeding at 20 and 40 DAS	100.0	96.7	100.0	95.7	100.00	98.3	-	-	-	-
Un-weeded check	-	-	-	-	-	-	-	-	-	-

Table 3. Yield and economics of wheat as influenced by different weed management practices (two years pooled data)

Treatment	Plant Population (per meter row length) at 15 DAS		Grain yield (t/ha)		Straw yield (t/ha)		B C ratio	
	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23	2021-22	2022-23
Pendimethalin 500 g/ha PE *fb* clodinafop-propargyl 60 g/ha PoE	58.1	53.9	5.29	4.88	7.44	7.19	2.91	2.70
Flumioxazin 125 g/ha PE *fb* clodinafop-propargyl 60 g/ha PoE	55.2	53.6	4.59	4.17	6.44	6.18	2.40	2.20
Pyroxasulfone 127.5 g/ha PE *fb* clodinafop-propargyl 60 g/ha PoE	53.0	54.5	5.02	4.28	7.09	6.20	2.52	2.16
Pendimethalin 500 g/ha PE *fb* sulfosulfuron30 g/ha PoE	56.7	53.7	4.63	4.58	6.42	6.19	2.50	2.47
Pendimethalin + metribuzin (TM) 500 + 140 g/ha PE	56.3	51.6	2.87	2.43	6.09	5.83	1.73	1.50
Clodinafop-propargyl + metsulfuron-methyl (PM) 60 + 4 g/ha PoE	59.7	57.0	5.26	4.83	7.28	7.16	2.92	2.71
Sulfosulfuron + metsulfuron-methyl (PM) 30 + 2 g/ha PoE	58.5	56.7	5.23	4.54	7.24	7.03	2.93	2.58
Mesosulfuron-methyl + iodosulfuron-methyl sodium (PM) 12 + 2.4 g/ha PoE	59.9	56.9	4.45	3.95	6.43	6.15	2.51	2.25
Metribuzin + clodinafop-propargyl (PM) 140 + 40 g/ha PoE	58.9	56.6	3.64	2.99	6.18	6.17	2.13	1.81
Metribuzin + clodinafop-propargyl (PM) 210 + 60 g/ha PoE	59.0	55.0	3.55	2.87	5.93	6.09	2.05	1.72
Hand weeding at 20 and 40 DAS	58.3	54.4	5.18	4.83	7.21	7.12	2.54	2.38
Un-weeded check	59.3	56.1	1.94	1.75	3.07	2.87	1.19	1.08
LSD (p=0.05)	NS	NS	0.62	0.60	0.98	0.97	-	-

but due to phytotoxic effect on crop leads to reduction in grain and stover yield of wheat. The lowest yields of wheat with the highest yield reduction of grain yield to the extent of 63.41 and 64.04% was recorded during 2021-22 and 2022-23, respectively under un-weeded check due to severe crop-weed competition throughout the crop growth stages.

Economics

The economics analysis of the weed management practices revealed that higher benefit cost ratio was recorded under premix application of clodinafop-propargyl 15% + metsulfuron-methyl 1% WP (PM) 60 + 4 g/ha PoE followed by sulfosulfuron 75% + metsulfuron-methyl 5% WG (PM) 30 + 2 g/ha PoE and sequential application of pendimethalin 30% EC 500 g/ha PE *fb* clodinafop-propargyl 15% WP 60 g/ha PoE during both the years of experimentation.

Conclusion

The finding of the present study indicated that post-emergence application of either of clodinafop-propargyl 15% + metsulfuron-methyl 1% WP (PM) 60 + 4 g/ha or sulfosulfuron 75% + metsulfuron-methyl 5% WG (PM) 30 + 2 g/ha PoE provides effective control of *P. minor* with broad-spectrum weed control resulting higher grain yield and benefit-cost ratio. Similar effectiveness was observed under sequential application of pendimethalin 30% EC 500 g/ha PE *fb* clodinafop-propargyl 15% WP 60 g/ha PoE or sulfosulfuron 75% WP 30 g/ha PoE and hand weeding at 20 and 40 DAS. Therefore, for long-term management, these options can be used in a yearly rotation.

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