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Efficacy of Preemergence and Postemergence Herbicides for Controlling Common Purslane

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***Abstract.* Common purslane (*Portulaca oleracea* L.) can be problematic in thin turf, along sidewalks and drives, and especially during turfgrass establishment. Little published research exists evaluating herbicides that will control purslane and are also labeled for turfgrass. Thus, our objective was to evaluate the efficacy of preemergence (PRE) or postemergence (POST) herbicides labeled for use in turf for controlling purslane. Experiments were conducted once in 2011 and twice in 2012 to evaluate nine PRE herbicides at one-half maximum and maximum label rates applied over immature perennial ryegrass (*Lolium perenne* L.). The PRE herbicides isoxaben and simazine consistently resulted in the best purslane control for all three PRE experiments. Experiments in 2011 and 2012 evaluated 25 POST herbicides at full label rates applied to mature purslane plants. The POST herbicides fluroxypyr, triclopyr, and metsulfuron-methyl were most effective in controlling purslane.**

Turfgrasses that establish quickly can resist weed colonization, and stands with high turf density may reduce weed competition (Busey, 2003). Conversely, stresses that thin turf and expose the soil to sunlight could allow annual weed infestation (Busey, 2003). Common purslane (*Portulaca oleracea* L.) is a warm-season summer annual weed often found in thin turf, bare soil areas (Matthews et al., 1993), or during turfgrass establishment.

For spring establishment of turfgrass or in thin turf along sidewalks and drives, herbicide control of purslane may be necessary. Labels of many turfgrass herbicides list purslane as a weed species controlled, but limited published research is available on herbicide control of purslane in turf. Several studies in crops other than turfgrass have evaluated purslane control with herbicides, but often only report limited purslane data because it was not the primary target and/or because this weed appeared inconsistently during the studies. Of the research reported, few of the mentioned herbicides are labeled for use in turf, whereas others are not labeled for use in the United States.

Among the products labeled for use in turf, Stacewicz-Sapuncakis et al. (1973) found that purslane was sensitive to the POST herbicide dicamba, but the lethal rate depended on plant age. Postemergence applications of clopyralid resulted in less than 45% control of purslane at harvest of leafy greens (Norsworthy and Smith, 2005), but clopyralid is no longer labeled for use on residential lawns. An evaluation of PRE herbicides for weed control in pumpkin (*Cucurbita* spp.) found sulfentrazone or dimethenamid resulted in 74% or greater control of purslane 21 d after treatment (Brown and Masiunas, 2002). Bensulide or pronamide applied PRE reduced purslane density in lettuce (*Lactaca sativa*) by 52% to 98% (Haar and Fennimore, 2003). Preemergence application to control purslane in leafy greens with pendimethalin resulted in greater than 84% control, whereas bensulide plus dimethenamid resulted in less than 78% control (Norsworthy and Smith, 2005).

Among herbicides for controlling purslane that are not labeled in turfgrass or not for use in the United States, POST herbicides nitrofen and oxyfluorfen increase membrane permeability resulting in stomatal closure, membrane disruption, ethylene synthesis, and ultimately leaf abscission in purslane (Gorske and Hopen, 1978). Doohan and Felix (2012) report between 11% and 95% purslane control in green onion with oxyfluorfen applied at three labeled rates. Postemergence treatments with phenmedipham resulted in less than 45% control of purslane at harvest of leafy greens (Norsworthy and Smith, 2005). The PRE herbicides diethatyl, diphenamid, diethatyl plus diphenamid, or S-metolachlor reduced purslane in vegetable crops (Cavero et al., 1996; Norsworthy and Smith, 2005). Imazethapyr applied either PRE or POST in lettuce provided greater than 80% PRE control and greater than 85% POST control of purslane (Dusky and Stall, 1996). The soil fumigant methyl iodide was as effective as methyl bromide in reducing purslane seed germination rates in a laboratory study for the two highest rates tested (Ohr et al., 1996). Because many previously researched herbicides are not currently labeled for use in turf, the objective of our study was to conduct herbicide screens to determine the efficacy of PRE or POST herbicides labeled for turfgrass to control purslane.

Materials and Methods

Preemergence and POST herbicide studies were conducted in 2011 and 2012 at the University of Nebraska–Lincoln's John Seaton Anderson research facility near Mead, NE. Soil was a Tomek silt loam (Fine, smectitic, mesic Pachic Argiudolls) with pH 6.8 and 3.1% organic matter. Experimental areas were tilled in July the year before herbicide treatment to encourage purslane establishment.

Preemergence experiments were conducted in 2011 (PRE2011) and twice in 2012 (PRE2012a and PRE2012b). Plot areas were seeded with 195 $kg \cdot ha^{-1}$ of perennial ryegrass (*Lolium perenne* L.) in late September preceding herbicide application the next spring. The perennial ryegrass was killed with glyphosate at 3.1 kg a.i./ha 7 (± 3) d after experimental treatments were applied to limit competition and encourage purslane. Herbicide treatments for PRE2011 were applied 20 Apr. 2011. As a result of an unusually warm spring, herbicide treatments for PRE2012a were applied on 29 Mar. at a similar growing degree-day accumulation (300 ± 50 GDD base 10 °C) as PRE2011 and a third experiment, PRE2012b, was applied on 24 Apr. 2012 (Fig. 1). For each experiment, nine PRE herbicides were applied once at maximum and half maximum label rates (Table 1) and watered in immediately after treatment with 2.5 mm irrigation. Herbicides were applied to plots measuring 1.5 × 1.5 m using a CO_2 pressurized sprayer with three flat fan nozzles (LF8002; TeeJet Spraying Systems, Wheaton, IL) at 817 $L \cdot ha^{-1}$ and 207 kPA. Purslane emergence was first noted on 2 June for PRE2011, 2 May for PRE2012a, and 14 May for PRE2012b. Percent purslane cover was visually estimated at 6, 8, and 10 weeks after treatment (WAT). Before analysis, percent of the control was calculated as 1 – (treated percent cover/untreated percent cover) *100 Eq. [1] for each of the rating periods. Plot areas were watered with 7.6 mm irrigation once every 2 weeks. Chlorantraniliprole at 0.28 $kg \cdot ha^{-1}$ was applied on 21 June 2011 and 22 May and 14 June 2012 to prevent white-line sphinx (*Hyles lineata*) infestation.

Postemergence experiments were conducted in 2011 (POST2011) and 2012 (POST2012). Plot areas were tilled in late April to control winter annuals or early-germinating summer annuals and purslane was encouraged to naturally invade plot areas with light watering and hand-weeding of non-purslane weed species. On 15 June 2011 and 4 June 2012, 25 different herbicides were applied at the high label rate to purslane plants with 10-cm or greater main stem length (Tables 2 and 3). Eight of the herbicides were applied both with and without the label-recommended surfactants, and the surfactants were also applied alone as standards. Herbicides were applied to plots measuring 1.5 × 1.5 m using a CO_2 pressurized sprayer with three flat fan nozzles at 817 $L \cdot ha^{-1}$ and 207 kPa.

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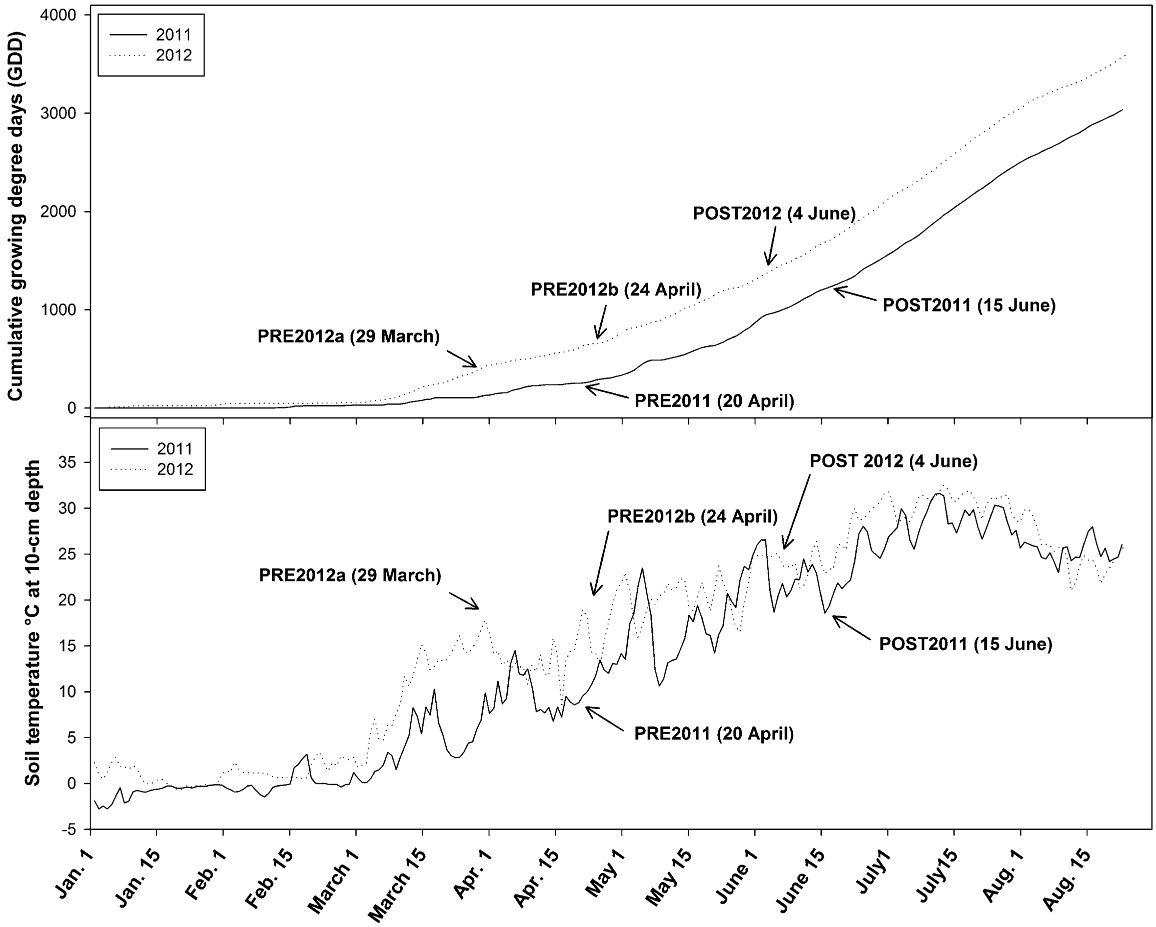

Fig. 1. Cumulative growing degree-days (GDD) using base 10 °C model and soil temperatures recorded at 10-cm depth from 1 Jan. to 31 Aug. in 2011 and 2012 at the University of Nebraska–Lincoln John Seaton Anderson turfgrass research facility near Mead, NE. Herbicide application dates for the PRE2011, PRE2012a, PRE2012b, POST2011, and POST2012 studies are indicated.

Table 1. Percent purslane control by experiment following preemergence herbicide treatments.

	Herbicide		Purslane control				
	Half maximum label rate	Maximum label rate	PRE2011[z]	PRE2012a		PRE2012b	
			8 WAT[y]	8 WAT	10 WAT	8 WAT	10 WAT
Common name	(kg a.i./ha)		(%)				
Dimethenamid	0.8	1.6	18 de[x]	37 b	29 b	46 cd	20 c
Dithiopyr	0.3	0.6	41 bcd	36 b	20 b	41 cd	10 c
Ethofumesate	1.7	3.4	61 b	89 a	80 a	32 d	13 c
Isoxaben	1.0	2.0	98 a	65 ab	62 ab	96 a	82 ab
Mesotrione	0.1	0.2	14 e	37 b	29 b	31 d	2 c
Pendimethalin	1.0	2.1	24 cde	55 ab	34 ab	63 bc	19 c
Prodiamine	0.8	1.6	45 bc	66 ab	63 ab	87 ab	63 b
Siduron	27.4	54.8	18 de	41 ab	40 ab	28 d	3 c
Simazine	1.4	2.8	99 a	57 ab	40 ab	98 a	92 a
Untreated[w]	—	—	53	5	14	28	48

[z]Herbicides for PRE2011, PRE2012a, and PRE2012b were applied on 20 Apr. 2011, 29 Mar. 2012, and 24 Apr. 2011, respectively.
[y]WAT = weeks after treatment.
[x]Means of two herbicide rates and three replications. Means with a column followed by the same letter are not significantly different according to Fisher's least significant difference at $P \leq 0.05$.
[w]Untreated means show percent purslane cover used to calculated purslane control.

The PRE herbicide isoxaben was applied at 1 $kg \cdot ha^{-1}$ on 17 June 2011 and 5 June 2012 over all treatments to limit emergence of new purslane after POST application. Percent purslane cover was visually determined at 1, 2, 3, and 4 WAT. Percent of the control was calculated using Eq. [1] as described previously. Plot areas were watered with 7.6 mm irrigation once every 2 weeks. Chlorantraniliprole at 0.28 $kg \cdot ha^{-1}$ was applied on 21 June 2011 and 1 June 2012 to prevent white-line sphinx infestation.

Treatments in all research trials were arranged as a randomized complete block with three replications. The PRE study was a nine × three × two factorial with nine herbicide treatments, three experimental runs, and two herbicide rates. The POST study had two factors, herbicide treatment and experimental run. Data were analyzed as a general linear model, which assumes homogeneous variance; however, variance for some factors such as year or experiment tends to be heterogeneous. Therefore, within each study (PRE or POST), variance for each experiment was modeled separately using PROC GLIMMIX in SAS (SAS Institute, 2009) to account for heterogeneous

Table 2. Percent purslane control in 2011 after postemergence herbicide treatments.

Herbicide[z]		Purslane control			
	Rate	1 WAT[y]	2 WAT	3 WAT	4 WAT
Common name	(kg a.i./ha)	(%)			
Fluroxypyr	0.31	98[x] a	100 a	100 a	100 a
Metsulfuron methyl + NIS[w]	0.04	88 ab	100 a	100 a	100 a
Triclopyr	1.55	95 a	100 a	100 a	100 a
Dicamba	1.36	74 abcd	98 ab	99 a	99 a
Glyphosate	4.16	98 a	100 a	99 a	99 a
Glufosinate	1.12	98 a	100 a	100 a	98 a
MCPA	2.52	76 abcd	98 ab	97 ab	94 a
Flazasulfuron + NIS	0.06	92 a	99 ab	97 ab	93 a
Aminocyclopyrachlor	0.08	33 fg	67 defg	83 abcd	90 ab
Clopyralid	0.56	35 fg	62 fgh	76 cd	88 ab
Ethofumesate	0.86	75 abcd	98 ab	96 abc	85 ab
Carfentrazone	0.03	96 a	95 abc	86 abcd	74 bc
2,4-D	2.51	51 defg	80 bcdef	78 bcd	66 c
Formasulfuron + MSO[v]	1.05	59 bcdef	81 bcde	66 de	39 e
Diquat dibromide + NIS	0.06	87 ab	82 abcd	52 ef	40 e
Sulfentrazone	0.28	83 abc	78 cdef	51 ef	35 f
Sulfosulfuron + NIS	0.07	61 bcdef	75 defg	37 fg	29 fg
Dithiopyr	0.57	57 cdef	63 efgh	37 fg	22 fgh
Pyraflufen ethyl	0.01	81 abc	69 defg	30 fg	17 ghi
Simazine	2.24	46 efg	57 gh	17 ghi	10 hij
Fenoxaprop-P-ethyl	0.13	28 gh	16 ij	8 hi	5 hij
Penoxsulam	0.04	49 defg	45 h	24 gh	5 hij
Quinclorac + MSO	0.37	31 fg	23 i	8 hi	3 hij
MSMA + NIS	2.52	–3 hi	–3 j	1 i	0 ij
Mesotrione + NIS	0.28	–7 i	7 ij	2 i	–2 j
Untreated[u]	—	67	87	97	97

[z]Herbicides were applied on 15 June 2011. Isoxaben was applied at 1 kg·ha^{-1} over the top of all herbicide treatments 1 to 2 d after treatment.
[y]WAT = weeks after treatment.
[x]Means with a column followed by the same letter are not significantly different according to Fisher's least significant difference at $P \leq 0.05$.
[w]NIS = non-ionic surfactant.
[v]MSO = methylated seed oil.
[u]Percent purslane cover of untreated means shown for reference only.

variance and data for experiments were combined in one analysis (Littell et al., 2006). Mean separation was performed using Fisher's least significant difference at $P \leq 0.05$.

Results and Discussion

Preemergence study. At 6 WAT, there were no differences in purslane control between treatments, and all treatments had a mean value of less than 2% purslane cover (data not shown). For all remaining rating dates, there was a significant experiment-by-herbicide interaction; therefore, data are presented by experiment (Table 1).

In PRE2011, isoxaben and simazine provided the highest purslane control at 8 WAT (Table 1). On 18 June 2011, feeding from white-line sphinx caterpillars was found in PRE2011 and damage was inconsistent across the plot area. Ratings after 8 WAT for PRE2011 were confounded and thus not reported. Six of the nine and two of the nine herbicides provided the best purslane control at 10 WAT in PRE2012a and 2012b, respectively. For experiments in 2012, isoxaben, simazine, and prodiamine were most effective in controlling purslane cover at both 8 and 10 WAT. Norsworthy and Smith (2005) reported slightly better control (greater than 84% control) with pendimethalin than was found in our experiments. Brown and Masiunas (2002) and Norsworthy and Smith (2005) also noted poor control with dimethenamid as we found in our study. Although we attempted to synchronize our PRE herbicide applications between years by either GDD or calendar date, purslane cover for the control ranged from 5% to 53% when rated at 8 WAT across the three experiments. Discrepancy in purslane cover between the control plots was primarily the result of environmental differences despite our effort to adjust for it. Natural variation exists in the amount and dormancy of purslane seed in the soil seed bank, which also could have affected the purslane cover (Egley, 1974). Regardless, we identified two herbicides, isoxaben and simazine, that were always in the statistical group that resulted in the best purslane control across all three PRE experiments (Table 1).

Postemergence study. Statistical analysis showed no difference in purslane control between herbicides applied with or without label-recommended surfactants or between the isoxaben-treated or untreated controls; thus, only treatments including the label-recommended surfactant and the isoxaben-treated control were included in the final analysis. Like the PRE experiments, there was a significant experiment-by-herbicide interaction for purslane control in the POST study; thus, data are presented by experiment (Tables 2 and 3). Although many treatments reduced purslane cover compared with the control during the two experiments, fluroxypyr and triclopyr were the only two herbicides that resulted in the highest control at each rating date in both experiments (Tables 2 and 3). By 4 WAT in both experiments, fluroxypyr, metsulfuron-methyl, and triclopyr resulted in the best purslane control, although control from several other herbicides was statistically similar to these treatments in POST2011. Fluroxypyr at 0.3 kg a.i./ha also provided 100% purslane control in sorghum (Love, 1993), whereas Durr (2012) documents greater than 60% purslane control with metsulfuron-methyl applied at 4.2 g·ha^{-1}. Similar to our data, others note clopyralid and mesotrione applied POST result in poor purslane control (Norsworthy and Smith, 2005; Pannacci and Covarelli, 2009).

There was some variation in herbicide performance among the POST experiments, which may be the result of maturity of the plants at application. Stacewicz-Sapuncakis et al. (1973) found that efficacy of dicamba decreased with increased age and size of purslane. In our study, percent cover of purslane was 33% to 60% at the time of application in POST2011 compared with 88% to 95% cover in POST2012 (data not shown) as a result of purslane plants being more mature when herbicides were applied in POST2012 compared with POST2011. This is despite the fact that POST2012 herbicide applications were made earlier to account for earlier plant maturity in 2012 (Fig. 1). There were more herbicides in the statistically best-performing group at every rating date in POST2011 (Table 2) than in POST2012 (Table 3). This may be attributed to smaller and more susceptible plants in POST2011 compared with POST2012. In 2011, 11 of 25 herbicides were in the statistically best-performing group (15% cover or less) by 4 WAT compared with 95% cover in the control. However, in 2012, only three herbicides were in the best-performing group (less than 17% cover) in 2012 at 4 WAT compared with 97% in the control. Only the most effective herbicides reduced purslane cover when applied to the more mature plants in POST2012, reinforcing the findings of Stacewicz-Sapuncakis et al. (1973) of herbicides becoming less effective when applied to more mature purslane.

The effect of purslane maturity at the time of herbicide application is particularly important during turfgrass establishment where early herbicide applications could be more effective in controlling purslane, but applications often must be delayed to limit damage to turfgrass seedlings. The herbicide labels for dicamba, fluroxypyr, and triclopyr all require two to three mowings (4 weeks or more depending on turfgrass species) before applying over newly seeded cool-season turfgrass and metsulfuron-methyl requires 1 year before application to cool-season turf (Anonymous, 2007, 2008, 2010a, 2010b). However, carfentrazone can be applied as early as 7 d after emergence for most turfgrass and 14 d after emergence for zoysiagrass (*Zoysia* spp.) (Anonymous, 2009). Despite inconsistency from year to year in our study, carfentrazone resulted in 96% purslane control

Table 3. Percent purslane control in 2012 after postemergence herbicide treatments.

Herbicide[z]		Purslane control			
	Rate	1 WAT[y]	2 WAT	3 WAT	4 WAT
Common name	(kg a.i./ha)	(%)			
Fluroxypyr	0.31	44[x] a	79 a	99 a	100 a
Metsulfuron methyl + NIS[w]	0.04	–3 f	59 b	96 a	100 a
Triclopyr	1.55	40 ab	77 a	96 a	100 a
Dicamba	1.36	12 def	34 cd	49 b	83 b
Glyphosate	4.16	29 abc	45 c	81 a	79 b
MCPA	2.52	23 bcd	24 de	32 bc	38 c
Simazine	2.24	12 def	10 fgh	15 cdef	37 c
Penoxsulam	0.04	20 cde	8 fgh	4 def	21 d
Aminocyclopyrachlor	0.08	–1 f	1 gh	24 cd	14 de
2,4-D	0.56	13 de	14 efg	17 cdef	14 de
Clopyralid	2.51	–3 f	–1 h	3 ef	14 de
Sulfosulfuron + NIS	0.07	11 def	2 gh	3 ef	14 def
Glufosinate	1.12	32 abc	38 c	23 cde	9 def
Ethofumesate	0.86	3 f	15 ef	15 cdef	8 def
Formasulfuron + MSO[v]	0.06	7 e f	12 efgh	3 ef	5 def
Flazasulfuron + NIS	0.06	5 ef	10 fgh	2 f	3 ef
MSMA + NIS	0.03	11 def	5 fgh	1 f	3 ef
Carfentrazone	1.05	11 def	3 fgh	0 f	3 ef
Diquat dibromide + NIS	2.52	18 cde	–1 h	–1 f	3 ef
Quinclorac + MSO	0.37	–1 f	2 g h	–1 f	3 ef
Sulfentrazone	0.28	3 f	–3 h	0 f	0 ef
Pyraflufen ethyl	0.01	–1 f	0 h	–1 f	0 ef
Dithiopyr	0.57	–2 f	–1 h	–1 f	–2 ef
Mesotrione + NIS	0.28	–2 f	0 h	0 f	–2 ef
Fenoxaprop-P-ethyl	0.13	0 f	–1 h	–1 f	–4 f
Untreated[u]	—	92	97	98	94

[z]Herbicides were applied 4 June 2012. Isoxaben was applied at 1 $kg \cdot ha^{-1}$ over the top of all herbicide treatments 1 to 2 d after treatment.
[y]WAT = weeks after treatment.
[x]Means with a column followed by the same letter are not significantly different according to Fisher's least significant difference at $P \leq 0.05$.
[w]NIS = non-ionic surfactant.
[v]MSO = methylated seed oil.
[u]Percent purslane cover of untreated means shown for reference only.

1 WAT for PRE2011 and is one of the safest herbicide options at turfgrass establishment. If applied to young purslane or potentially in multiple applications, carfentrazone may be useful for situations in which turfgrass seedling safety is a concern to manage purslane until a more effective herbicide can be applied.

Results indicate fluroxypyr, triclopyr, and metsulfuron-methyl applied POST are most effective for controlling purslane in turfgrass stands. For extended purslane control, isoxaben or simazine applied PRE was shown to be effective and could be combined with any of the effective POST herbicides to ensure control of escaped purslane. Under the conditions tested, not all herbicides were effective in controlling purslane and purslane maturity at the time of application appears to influence the efficacy of many POST herbicides. Future work evaluating the effect of herbicide application timing, multiple herbicide applications, or use of combination products would be helpful in developing more complete control recommendations.

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