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IMPACT OF VARIOUS DOSES OF BUTACHLOR ON WEED GROWTH, CROP YIELD OF RICE, MICROBIAL POPULATION AND RESIDUAL EFFECT ON WHEAT CROP

V. Pratap Singh, Neeshu Joshi, Neema Bisht, A. Kumar, Kavita Satyawali and R.P. Singh

Department of Agronomy, College of Agriculture,
G.B. Pant University of Agriculture and Technology, Pantnagar
E-mail: vpratapsingh@rediffmail.com

Abstract: A field investigation was carried to test the bioefficacy of Butachlor 50 EC at various doses (Sponsor Vs market sample) to control the weeds in transplanted rice. Butachlor was applied at various doses as pre emergence and its market sample used at two doses, almix also applied as post emergence. All weed control treatments significantly reduced the density as well as dry matter accumulation of weeds over weedy check during both the years. The maximum suppression of density as well as dry matter accumulation of weeds and highest WCE were obtained with application of Butachlor 50% EC at higher doses (2000 and 4000 g/ha) as compared to its lower dose 1250 g/ha. Among herbicidal treatments maximum grain (4479 and 5056 kg/ha) and straw (7370 and 6963 kg/ha) yield was achieved by the application of Butachlor 50 EC (SS) at 2000 g/ha applied as pre emergence during both the years.

Keywords: Bio-efficacy, Butachlor, microbial, residual and transplanted rice.

Introduction

Rice (*Oryza sativa* L.) is a staple food for more than 60% of the world's population. Feeding the 9 billion people expected to inhabit our planet by 2050 will be an unprecedented challenge for the mankind. In India, rice is cultivated in an area of 44.07 m ha annually with a production of 103.40 mt, with an average productivity only 2.3 t/ha (FAO, 2012). There are several reasons for low productivity, however it has been estimated that without weed control, the yield loss can be as high as upto 90%. Weeds have caused yield reduction of 28 to 45% in transplanted rice (Singh *et al*., 2007; Manhas *et al*., 2012). High density of grassy weeds competing with crop and resulting into heavy yield losses up to 40-50% (Singh *et al*., 2004). Furthermore, any delay in weeding will lead to increased weed biomass which has a negative correlation with yield. The reduction in weed growth was observed with intensive puddling and shallow depth submergence in transplanted rice **(Reddy and Reddy, 1999).** Transplanted rice faces diverse type of weed flora, consisting of grasses, broad-leaf weeds

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and sedges. Weed competition brings reduction in yield of transplanted rice by about 50 per cent (**Mukherjee and Singh, 2005).**

Manual weeding is although effective and most common method, however, scarcity and high wages of labor particularly during peak period of critical competition between weed and crop period make this method uneconomical. The goal of herbicide use is to kill or stunt weed infestation allowing the rice to grow and gain a competitive advantage. Weeds are the most important biological constraint to decrease the yield of rice. Now chemical weed control method is becoming popular among the farmers because it is the most efficient means of reducing weeds competition with minimum labor cost. Butachlor, anilofos, oxadiargyl, etc. are the herbicides presently use for weed control in transplanted rice. Weed density per unit area is an important and key parameter in figuring out the impact of treatments on weed growth. Moreover, the use of herbicides, though discouraged worldwide these days because of environmental and health hazards, is inevitable due to many reasons particularly in the terms of economics and the immediate effect. Bio-efficacy of herbicides is also depends on herbicide doses and affect the crop physiology, soil health and residue effect on succeeding crop. With this thought keeping in background, the present research work on bio-efficacy of butachlor 50% EC of sponsor Vs market samples tested in transplanted rice to find out the herbicide efficacy at various doses and its impact on crop and soil health along with carryover of residues in succeeding wheat crop.

Materials and Methods

The field experiment was conducted at N.E. Borlaug Crop Research Centre of G.B. Pant University of Agriculture and Technology, Pantagar during two consecutive year of 2010-11 and 2011-12. The Crop Research Centre where the experiment was conducted is located at 29^{o} N latitude, 79.3^{o} E longitude, and at an altitude of 283.84 metres above the mean sea level. The soil was loamy, medium in organic matter (0.67%), available phosphorus (17.5 kg/ha) and potassium (181.2 kg/ha) with pH 7.5. The experiment consisted of eight treatments including untreated (control) and laid out in randomized block design (RBD) with three replications. The treatments were as follows of Butachlor 50% EC (sponsor sample) at 1250, 2000, 4000 g/ha and two doses of market sample at 1250 and 2000 g/ha applied as pre emergence, Almix 20%WP at 4 g/ha applied as post emergence to required volume of water 500 l/ha. Weed free and weedy check also included in experiment to compare the efficacy of herbicidal treatments. Rice variety “Sarjoo 52” seedling was planted on June 2 of *kharif* 2010 and June 10 of *kharif* 2011. The other agricultural practices used for rice transplanting in the

region were followed. Knap sack sprayer fitted with boom along with flat fan nozzle was used to apply the herbicidal solution. The basal dose was applied at the rate of 60:60:40:25 kg/ha of N:P:K and Zn, respectively. Weed were recorded species wise in each plot at 30 and 60 days after transplanting (DAT) with the help of quadrate of 0.25m^2 for the area marked for observation. The weed after uprooting are cleaned and dried in oven at 72^{0}C temperature and weed control efficiency was calculated by using the formula WCE = (weed biomass in unwedded control– weed biomass in managed treatment)/ weed biomass in unweeded control x 100. Besides observations for plant height, tillers (number/row), panicles/m^2, grains/panicle, 1000 grain weight, grain and straw yield were taken. Data recorded were statistically analyzed according to Gomez and Gomez (1984). Means were compared at 5% levels of significance by the least significant difference (LSD) test.

Result and Discussion

Weed flora

The dominant weed flora of the experimental site at 30 and 60 DAT was similar during both years and comprised of grasses; *Echinochloa colona, Echinochloa crusgalli, broad leaf weeds; Ammania baccifera, Caesulia auxillaris, Alternanthera sessilis* and *Cyperus spp*. was the only species among the sedge.

Effect on weeds

Weed density and weed dry matter varied significantly under different herbicidal treatments (Table 1&2). Data presented in Table 1&2 indicated that all the herbicidal treatments significantly reduced the density and dry matter accumulation of weeds with increasing the dose of Butachlor 50% EC (Sponsor sample) as compared to market sample of Butachlor 50% EC at both stages during both the years except at 30 DAA in 2010 over the weedy check and thus ultimately enhanced weed control efficiency. Prakash *et al*., 2013 also observed that Butachlor 1500 g/ha significantly reduced the density and dry weight of weeds over weedy check (control). Maximum reduction in weed density and dry weight of weeds was obtained with application of Butachlor 50% EC (SS) 4000 g/ha followed by its lower dose 2000 g/ha. Application of Butachlor 50% EC at 1250 and 2000 g/ha (SS) was found more effective in reducing the population of grassy weeds over the market sample of butachlor at same doses.

Weed dry matter is a better parameter to measure the competition than the weed number (Bhanumurthy and Subramanian, 1989). The total dry matter accumulation of weeds reduced is an indication of the overall utilization of resources and better light interception. Application of Butachlor either SS or MS both significantly reduced weed population as well

as weeds dry matter accumulation found in rice crop over weedy check during both the years of experimentation. The lower weed dry weight in weed control treatments may be ascribed to lesser number of weeds, rapid depletion of carbohydrates reserves of weeds through rapid respiration (Hill and Santlemann, 1969). Among various herbicides, Butachlor 50% EC (SS) at 4000 g/ha recorded the lowest weed dry matter accumulation followed by its lower dose at 2000 g/ha at both the stages of crop growth due to elimination of both grassy and non-grassy weeds resulting in maximum weed control efficiency. While Almix 20% WP 4 g/ha was least effective with lowest weed control efficiency as it was not effectively control the grassy weeds.

Table 1: Effect of treatments on density and total dry weight of weeds at 30 DAA during 2010 and 2011

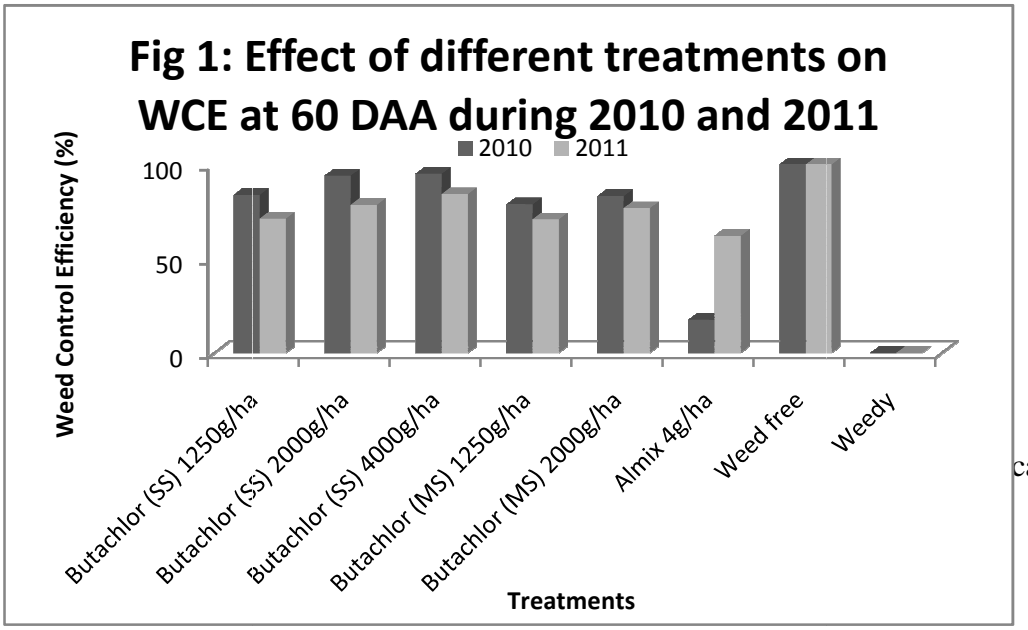
Treatments	Dose (g/ha)	2010								2011						
		Weed density (no./m^2) at 30 DAA							Total weed dry Weight (g/m^2)	Weed density (no./m^2) at 30 DAA						Total weed dry weight (g/m^2)
		E. colona	*E. crusgalli*	*I. rugosum*	*A. basifera*	*C. axillaris*	*A. sessalis*	*Cyperus spp.*		*E. colona*	*E. crusgalli*	*I. rugosum*	*A. basifera*	*C. axillaris*	*A. sessalis*	
Butachlor50% EC(SS)	1250	1.1(2.7)	2.1(8.0)	0.0(0.0)	0.0(0.0)	1.5(5.3)	2.7(13.3)	0.0(0.0)	14.8	1.0(2.7)	0.5(1.3)	0.0(0.0)	1.0(2.7)	2.3(9.3)	0.0(0.0)	27.1
Butachlor 50% EC (SS)	2000	0.0(0.0)	1.3(4.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	2.4(10.7)	0.0(0.0)	13.4	0.5(1.3)	0.0(0.0)	0.0(0.0)	1.0(2.7)	2.1(8.0)	0.0 (0.0)	22.7
Butachlor 50% EC (SS)	4000	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.7(2.7)	2.3(9.3)	0.0(0.0)	7.6	0.5(1.3)	0.0(0.0)	0.0(0.0)	0.5(1.3)	2.3(9.3)	0.0(0.0)	19.4
Butachlor 50% EC (MS)	1250	0.0(0.0)	2.9(17.3)	0.0(0.0)	0.0(0.0)	0.0(0.0)	2.6(12.0)	0.0(0.0)	14.8	1.0(2.7)	1.6(4.0)	0.0(0.0)	1.0(2.7)	2.1(8.0)	1.0(2.7)	27.6
Butachlor 50% EC (MS)	2000	0.0(0.0)	1.3(4.0)	0.0(0.0)	0.0(0.0)	0.5(1.3)	2.7(13.3)	0.5(1.3)	12.7	0.5(1.3)	0.5(1.3)	0.0(0.0)	1.0(2.7)	2.3(9.3)	0.0(0.0)	22.9
Almix 20% WP	4	3.1(21.3)	4.0(52.0)	2.9(17.3)	0.0(0.0)	2.2(8.0)	2.1(8.0)	2.5(12.0)	35.0	1.8(5.3)	2.8(16.0)	0.0(0.0)	0.0(0.0)	1.4(5.3)	0.0(0.0)	52.8
Weed free	-	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0
Weedy	-	4.5(88.0)	4.4(82.7)	1.5(5.3)	1.5(5.3)	0.0(0.0)	0.7(2.7)	3.4(29.3)	84.3	2.1(7.3)	3.0(21.3)	1.7(4.7)	2.4(10.7)	2.7(14.7)	3.1(21.3)	93.2
LSD(0.05)		**0.5**	**1.1**	**1.1**	**0.8**	**1.3**	**0.9**	**0.6**	**12.3**	**1.1**	**0.8**	**0.1**	**1.2**	**0.8**	**0.5**	**6.9**

SS- Sponsor sample, **MS** – Market sample, Values in parentheses are original which were transformed to log (X+1) for analysis, DAA- days after herbicide application.

Table 2: Effect of treatments on density and dry weight of weeds at 60 DAA during 2010 and 2011

Treatments	Dose (g/ha)	2010							2011						
		Weed density (no./m^2) at 60 DAA						Total weed dry Weight (g/m^2)	Weed density (no./m^2) at 60 DAA						Total weed dryweight (g/m^2)
		E. colona	*E. crusgalli*	*A. basifera*	*C. axillaris*	*A. sessalis*	*Cyperus spp.*		*E. colona*	*E. crusgalli*	*I. rugosum*	*A. basifera*	*C. axillaris*	*A. sessalis*	
Butachlor50% EC(SS)	1250	0.0 (0.0)	1.3 (4.0)	0.0 (0.0)	0.0 (0.0)	1.1 (2.7)	2.5 (10.7)	41.1	0.7(1.3)	2.1(7.3)	0.7(1.3)	1.3(2.7)	1.6(4.0)	3.1(21.3)	45.5
Butachlor 50% EC (SS)	2000	0.0 (0.0)	1.1 (2.7)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2.7 (14.7)	12.9	0.0(0.0)	1.7(4.7)	0.0(0.0)	0.0(0.0)	0.5(1.3)	3.2(25.3)	34.0
Butachlor 50% EC (SS)	4000	0.5(1.3)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	2..4(10.7)	12.5	0.0(0.0)	1.0(2.7)	0.0(0.0)	0.0(0.0)	0.0(0.0)	3.2(24.0)	24.9
Butachlor 50% EC (MS)	1250	2.0 (6.7)	2.7(13.3)	0.0 (0.0)	1.1 (2.7)	1.1 (2.7)	2.7 (13.3)	54.1	1.2(2.7)	2.1(8.0)	0.7(1.3)	1.3(2.7)	1.6(4.0)	3.1(22.7)	46.1
Butachlor 50% EC (MS)	2000	1.1 (2.7)	0.7 (2.7)	0.0 (0.0)	0.0 (0.0)	2.0 (6.7)	3.0 (20.0)	42.7	0.7(1.3)	0.0(0.0)	0.0(0.0)	0.0(0.0	0.0(0.0)	3.0(20.0)	36.8
Almix 20% WP	4	2.3 (9.3)	3.9(49.3)	2.0 (6.7)	0.0 (0.0)	0.0 (0.0)	1.1 (2.7)	211.3	0.0(0.0)	2.1(8.0)	1.8(5.3)	0.0(0.0	0.0(0.0)	0.0(0.0)	60.9
Weed free	-	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.0	0.0(0.0)	0.0(0.0)	0.0(0.0)	0.0(0.0	0.0(0.0)	0.0(0.0)	0.0
Weedy	-	2.5(10.7)	3.9(50.7)	2.0 (6.7)	2.7(14.7)	2.0 (6.7)	2.1 (8.0)	256.5	1.8(5.3)	3.1(21.3)	2.0(6.7)	1.8(5.3)	1.8(5.3)	2.6(17.3)	158.8
LSD(0.05)		**0.8**	**1.3**	**0.3**	**0.6**	**0.8**	**0.7**	**29.0**	**0.5**	**0.5**	**0.6**	**0.3**	**0.6**	**0.6**	**21.6**

SS- Sponsor sample, **MS** – Market sample, Values in parentheses are original which were transformed to log (X+1) for analysis, DAA- days after herbicide application.



cation.

All the treatments of weed control increase the weed control efficiency in respect to increase the doses of herbicide over weedy check (Fig 1). The results revealed that maximum weed control efficiency other than weed free treatment was obtained with application of Butachlor 50 EC (SS) at higher dose 4000 g/ha followed by its lower dose 2000 g/ha during both the years.

Table 3. Effect of herbicidal treatments on yield and yield attributes of rice crop.

Treatments	Dose (g/ha)	Panicles/m^2		Grains/ panicle		1000 grain weight(g)		Grain yield (kg/ha)		Straw yield (kg/ha)	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Butachlor 50% EC (SS)	1250	147	212	161	130	21.6	23.7	4139	4650	6771	6663
Butachlor 50% EC (SS)	2000	163	237	185	140	22.9	24.1	4479	5056	7370	6963
Butachlor 50% EC (SS)	4000	162	213	146	135	23.0	23.5	4089	4812	6589	6760
Butachlor50% EC (MS)	1250	143	211	155	127	23.7	23.7	4167	4583	6406	6500
Butachlor50% EC (MS)	2000	157	215	159	131	24.7	24.0	4427	4928	7084	6917
Almix 20% WP	4	140	194	153	118	23.4	24.1	3281	4349	6271	6322
Weed free	-	172	259	166	143	25.4	23.7	4505	4974	7451	6988
Weedy	-	134	172	158	97	23.9	22.7	3015	4096	6302	5390
LSD		16	30	14	18	NS	NS	350	273	525	352

Effect of herbicides on yield attributes and yield of rice

All the yield attributing characters except 1000 grain weight were influenced significantly due to various herbicidal treatments during both years (Table 3). Among the herbicidal

treatments, the highest value of yield attributing characters viz., panicles/m^2 and grains /panicle was recorded with application of Butachlor 50% EC (SS) at 2000 g/ha during both years. Grain yield is the principal and primary parameter for assessment of any weed control treatments applied in experimentations. Data on grain yield revealed that the all executed treatments out-weighted over the weedy check. Among the herbicidal application, Butachlor 50 EC (SS) 2000 g/ha performed the best by giving the highest grain yield of 4479 and 5056 kg/ha during 2010 and 2011, respectively which was comparable to weed free as well as butachlor (MS) at 2000 g/ha. During 2010 highest straw yield (7370 kg/ha) was achieved with the application of butachlor (SS) at 2000g/ha which was found at par with butachlor (MS) applied at 2000g/ha and weed free while in 2011, it was found maximum (6988 kg/ha) with weed free situation which was significantly superior to butachlor (MS) applied at 1250 g/ha, almix at 4g/ha and weedy check. The effective control of weeds starting from the early crop growth stage might have resulted in better growth and yield of rice. The variation in grain and straw yield under different treatments was the result of variation in weed density and weed control efficiency. Due to maximum infestation of weeds, the lowest grain yield of rice was recorded in the untreated control plots.

Effect on microbial activity of soil

A healthy population of soil microorganisms can stabilize the ecological system in soil (Chauhan *et al*., 2006) due to their ability to regenerate nutrients to support plant growth. Any change in their population and activity may affect nutrient cycling as well as availability of nutrients, which indirectly affect productivity and other soil functions (Wang *et al*., 2008). Before herbicidal application the population of bacteria, actinomycetes and fungi was not significantly affected by the treatments during 2011 while at harvest weed control measures had no significant effect on the population of bacteria during 2010 as well as on the population of actinomycetes and fungi during 2011. Maximum bacterial population was recorded with almix 20% WP at 4 g/ha before application and with butachlor 50% EC (MS) at the time of harvest which was found superior to all other herbicidal treatments except butachlor 50% EC (SS) applied at 4000 g/ha. During the year 2010, among herbicidal treatments, application of butachlor 50% EC (MS) at 1250 g/ha before application and application of butachlor 50% EC (SS) at 1250 g/ha at harvest achieved highest population of actinomycetes as well as fungi (Table 4).

Table 4: Effect of different treatments on microbial population at different stages

Treatment	Doses (g/ha)	Bacteria 10^{-7}				Actinomycetes 10^{-5}				Fungi 10^{-4}			
		BA		AH		BA		AH		BA		AH	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Butachlor 50% EC (SS)	1250	12.7	14.38	16.0	22.53	12.0	17.22	12.7	21.00	3.3	11.43	3.7	22.03
Butachlor 50% EC (SS)	2000	10.7	15.51	13.7	21.40	10.0	18.78	12.0	19.03	2.3	14.69	2.3	19.36
Butachlor 50% EC (SS)	4000	10.3	14.83	14.7	17.73	8.7	17.69	9.4	16.40	1.7	12.77	2.0	17.63
Butachlor 50% EC (MS)	1250	12.0	15.67	14.3	23.20	12.3	18.81	12.4	21.66	4.0	13.98	3.3	22.43
Butachlor 50% EC (MS)	2000	13.0	14.49	14.7	21.90	9.3	19.26	11.7	19.30	2.3	15.35	2.7	20.73
Almix 20% WP	4	13.3	13.25	14.7	20.26	10.7	19.36	12.0	20.46	4.0	16.40	3.0	21.63
Weed free	-	15.3	13.91	18.3	20.53	12.7	18.74	13.4	22.93	4.3	12.79	4.0	21.80
Weedy	-	14.0	14.37	15.7	23.10	14.7	16.62	15.0	20.46	3.7	16.72	4.7	22.76
Sem±	-	0.9	1.1	1.5	1.0	0.7	1.0	0.9	1.0	0.5	1.0	0.4	1.1
CD at 5%	**-**	**2.9**	**NS**	**NS**	**3.2**	**2.4**	**NS**	**2.7**	**NS**	**1.5**	**NS**	**1.3**	**NS**

BA- before application, AH- at harvest

Effect on succeeding wheat crop

All yield and yield attributing characters were not influenced significantly due to weed control treatments (Table 5) and they were statistically similar and at par to each other, including weedy check plots. Pre emergence application of Butachlor (sponsor sample as well as market sample) against weeds in rice crop during *kharif* season was safe for growing wheat crop.

Table 5: Residual effect of herbicides on succeeding crop (wheat)

Treatments	Dose g/ha	Plant height (cm)		No. Spikes (m^{-2})		Grains/ spike		1000 grain weight (g)		Grain yield (kg/ha)		Straw yield (kg/ha)	
		2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Butachlor 50% EC (SS)	1250	92.3	91.5	116	255	37.0	57.4	39.8	45.80	4083	3198	5708	6302
Butachlor 50% EC (SS)	2000	91.0	90.6	108	287	39.5	48.1	43.7	48.75	4150	3283	7458	7344
Butachlor 50% EC (SS)	4000	93.5	92.5	128	259	40.5	42.8	45.1	45.30	4250	3229	7208	6854
Butachlor 50% EC (MS)	1250	93.0	92.6	111	271	35.2	48.3	40.3	44.95	3875	2948	7500	7427
Butachlor 50% EC (MS)	2000	89.1	89.1	128	300	38.6	41.1	42.2	45.68	4000	3271	6750	7146
Almix 20% WP	4	91.6	92.0	100	298	38.1	49.5	43.6	47.06	3542	3000	7250	7167
Weed free	-	92.0	92.0	99	276	33.3	52.6	43.1	46.26	4167	3448	7625	7510
Weedy	-	95.2	95.5	109	284	40.7	45.4	41.7	46.90	3667	3062	7458	7105
CD at 5 %		**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

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