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EFFECT OF SOWING DATES ON YIELD AND YIELD COMPONENTS ON MUTANT-CUM-HYBRID LINES OF BREAD WHEAT

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Abstract

Twenty-one stable wheat mutant lines along with four check varieties viz., Sarsabz, Kiran-95, T.J.83 and Khirman were evaluated under normal and late sowing dates. The observations were recorded on phenological, morphological and meteorological parameters. Higher yield and improvement in various yield components were recorded at normal sowing as compared to late sowing. Six mutant lines showed superiority in yield than check varieties at normal sowings while three mutants produced more yield than check varieties except Sarsabz at late sowings. At normal sowing eleven mutant lines matured earlier than all check varieties including short duration variety T.J-83 whereas two mutant lines were earlier than Sarsabz and Kiran-95 and thirteen than T.J-83 and Khirman.

Introduction

Wheat is an important cereal crop of Pakistan. Current consumption of wheat in Pakistan is 23 million ton. The country has produced 23.52 million ton wheat during year 2006-07, the highest production in the history of country showing 10.5% increase production over previous cropping year (Anon., 2007). Production of wheat in the country still can be increased with better package of technology, improved seed of varieties and sowing wheat at proper time. Wheat yield is quite sensitive to late plantings. The late planting of wheat could be due to many reasons such as presence of previous crops such as rice, cotton and sugarcane in the field, water stress fertilizer and pure seed at the time of sowing (Sial *et al*., 2009; Mirbahar *et al*., 2009). Wheat planted late usually faces high temperature during its grain filling period which ultimately results into lower crop yield. Akhtar *et al*., (2006) reported that mid November sown wheat could produce maximum yield (3.05 ton/ha) as compared to early (mid-October) and late (mid-late December) sown (2.35 ton/ha). Delayed wheat planting resulted in serious decline in grain yield (De, *et al*., 1983; Sial *et al*., 2005; Arain *et al*., 1999). Elevation in temperature accelerate plant development while growth rate declined showing decline in leaf size, tillering capacity and spike size which ultimately result in low yield. (lungu *et al*., 2000; Mullarkey & Jones, 2000; Sial *et al*., 2001). The exposure of wheat crop to high temperature (28-32^{o}C) resulted in significant decrease (20% or more) in yield (Stone & Nicolas, 1994). High temperature in early stage of growth of crop affects node extension, ear development while temperature stress at anthesis causes premature leaf senescence, affect fertility and reduces grain development (Wardlaw *et al.*, 1980). The number of high yielding and stress tolerant varieties of many crops has been developed through mutation breeding. More than 2700 mutant varieties of different plants including cereal crops have been released throughout the world by using mutation-breeding techniques (Lagoda 2008; Maluszynski *et al.*, 1991; Arain *et al.*, 2001; Anon., 2008). Present studies were therefore conducted to evaluate the performance of mutant lines at varying sowing dates. The studies will be useful to identify heat-tolerant mutant lines.

Material and Methods

Twenty-one stable mutant lines (selected from F_6M_5 generation) developed through intraspacefic crosses cum radiation-induced mutagenesis were evaluated with four check varieties (Sarasabz, Kiran-95, T.J83, Khirman) under two sowing dates during 2005-06. The normal sowing was conducted on 14th November and late on 23rd December 2005 at Nuclear Institute of Agriculture (NIA) Tando Jam. Experiments were laid out in randomized complete block design (RCBD) with four replications. Each genotype was sown in four rows of 3m long (net plot size $3.6m^2$). Daily minimum and maximum temperature and humidity was recorded throughout the season at wheat experimental station. Phenological traits viz., day to heading (noted when 80% spikes extruded from spikes), grain filling period (calculated by subtracting number of days to heading from days to maturity), days to maturity (counted when grains fully dried and ripened) and morphological traits *viz*., plant height, 1000-grain weight and grain yield (kg/ha) were recorded from each genotype. A net plot size of $3m^2$ was harvested to record grain yield. Five plant from each genotype and experiment were randomly selected to study the yield components viz., spike length, number of spikelet per spike, number of grains per spike and main spike yield. Data were statistically analyzed using analysis of variance (ANOVA) and Duncan’s Multiple Range Test (DMR’T) according to Steel & Torrie (1981).

Results

Results indicated highly significant ($p \leq 0.01$) differences among genotypes for various yield components at both sowing dates. Favorable temperatures were observed during both planting time (Table 1). During normal sown experiment, the minimum mean temperature was 13-15.7^{o}C while the maximum temperature recorded was 29.8-32.7^{o}C in November. During late sown experiment, the minimum mean temperature was 10-13.0^{o}C while the maximum temperature recorded was 21.5-26.5^{o}C in December. Early heat shocks might have negative effects on wheat crop such as reduction in tillering capacity. The heat stresses above normal limits alter plant functions and productivity. The high temperatures (35-37^{o}C) during grain filling period were recorded from the second to last week of March when most of the wheat entries were in their grain formation process (Table 1). The final grain weight of most of the wheat genotypes was severely affected both by water stress and terminal heat stresses; therefore their 1000-grain weight was very low. The highest temperatures (42^{o}C) were observed in the first week of April. These heat stresses at terminal ends forced maturity of the crop and could cause physiological and biochemical changes (Tashiro & Wardlaw, 1999; Slafer & Whitechurch, 2001). Grain yield, 1000-grain weight and some other yield components showed increase at normal sowing time as compared to late planting time.

Table 1. Meteorological data recorded during wheat crop season 2005-06 at TandoJam.

Months	Weeks	Minimum temperature (°C)		Maximum temperature (°C)		Humidity %	
		Range	Mean	Range	Mean	Range	Mean
October	1st	21-25	22.8	29-35	33.5	71-92	83.2
	2nd	15-17	16.0	31-34	32.0	65-91	80.2
	3rd	20-25	21.8	32-35	33.6	81-92	85.8
	4th	18-22	19.2	31-35	32.2	64-91	78.4
November	1st	12-15	14.4	28-31	29.8	53-78	64.0
	2nd	11-15	13.0	31-34	32.4	71-89	79.6
	3rd	13-16	14.8	32-33	32.7	64-91	78.8
	4th	15-17	15.7	29-32	30.7	82-91	87.5
December	1st	11-15	13.0	24-28	25.5	56-79	70.5
	2nd	10-12	11.2	24-29	26.5	68-79	75.8
	3rd	10-11	10.2	21-30	26.5	74-89	80.5
	4th	7-13	10.0	20-23	21.5	66-78	71.5
January	1st	6-10	8.4	21-22	21.2	78-89	85.6
	2nd	6-10	8.2	21-27	23.4	66-87	77.0
	3rd	4-12	6.8	15-25	21.2	74-88	80.0
	4th	4-9	6.8	16-22	20.2	62-88	79.0
February	1st	6-14	10.2	20-26	24.0	63-91	77.2
	2nd	12-15	13.5	20-28	25.0	89-95	91.7
	3rd	2-17	8.8	20-27	23.6	54-91	70.0
	4th	4-14	10.0	21-28	25.0	78-88	84.4
March	1st	14-17	15.3	25-28	26.7	88-90	89.2
	2nd	14-16	15.0	26-35	29.5	80-91	86.8
	3rd	16-21	18.7	34-37	35.2	82.91	85.0
	4th	14-19	16.50	34-37	35.3	58-84	71.8
April	1st	14-23	18.5	35-42	39.2	57-93	69.2
	2nd	10-19	14.4	32-38	35.2	55-91	69.2
	3rd	16-24	20.2	37-41	39.4	50-92	73.0
	4th	22-26	24.6	35-40	36.8	70-85	80.2

Phenological studies: Five mutant lines (MASR99-08, MASR99-11, MASR99-12 MASR99-14 MASR99-06) took significantly more days to heading (>79 days) than check varieties at normal sowing while seven genotypes utilized long time to ear emergence than three checks Sarsarbz, Kiran-95 and T.J-83. Eleven mutant lines matured earlier than all check varieties at normal sowing whereas two genotypes MASR99-08 and MASR99-13 ripened earlier than Sarsabz and Kiran-95 while 13 were earlier in maturity than T.J-83 and Khirman at late sown conditions. Grain fill period was reduced at late sowing. Four mutants (MASR99-16, MASR99-22, MASR99-23, MASR99-64) used more days to grain filling than check TJ-83 while 13 performed better than Sarsabz, Kiran-95 and Khirman at late sowing; could be more tolerant to high temperature stress than other genotypes (Tables 2 and 4).

Table 2. Phenological and agronomic traits of wheat mutant lines under normal sowing (14-11-2005).

Mutant lines	Days to heading	Days to maturity	Grain filling period	Plant height (cm)	1000-grain weight (g)	Grain yield (Kg/ha)
MASR99-01	74 gh	118def	44bcd	82def	35.7e	3540 h
MASR99-03	74 gh	116fgh	43def	106abc	33.5hij	4223 g
MASR99-06	79 c	116fgh	37 j	97abc	37.5d	5206 abc
MASR99-07	77 d	114jk	37 j	86cde	31.6k	2840 i
MASR99-08	83 a	113k	30 k	96abc	35.2efg	4923 abc
MASR99-09	71 j	115ijk	44cde	104abc	32.6j	5487 ab
MASR99-11	79 c	114jk	35 j	108abc	41.6bb	5240 abc
MASR99-12	82 b	123a	41 fgh	106abc	32.8j	4500 def
MASR99-13	71j	115ijk	44 cde	109abc	42.8a	5040 abc
MASR99-14	80 c	119cde	39 hi	75f	35.2ef	5197 abc
MASR99-15	72 ij	118cde	46 bc	95abc	37.6d	5163 abc
MASR99-16	76de	115ijk	40 ghi	111ab	34.4fgh	4303 fg
MASR99-17	72ij	117efg	45 bcd	103abc	38.3d	4820 abc
MASR99-18	73 hi	115ijk	42 efg	104abc	34.1ghi	4937 abc
MASR99-22	74 fgh	118cde	44 cde	91bcd	37.4d	5407 abc
MASR99-23	75efg	120bcd	45bcd	106abc	35.8e	4767 bcd
MASR99-31	69 k	120bc	51a	105abc	35.0efg	4373 efg
MASR99-37	79 c	122ab	43 def	104abc	35.2efg	4717 bcd
MASR99-64	71 j	116fgh	45bcd	111ab	40.3efg	4820 abc
MASR99-70	71 j	115ij	44cde	99abc	31.0k	2767 i
MASR99-72	74 fgh	119cde	45bcd	116a	33.3ij	3333 hi
Sarsabz	75 efg	119cde	45bcd	110ab	38.2d	5563 a
Kiran-95	75efg	120bcd	45bcd	105abc	39.4c	5037 abc
T.J-83	75efg	122ab	47 b	79ef	39.5c	4683 cde
Khirman	75efg	122ab	47b	104abc	38.2 d	4957 abc

Yield component studies: Plant height of wheat genotypes significantly reduced at late sowing. One thousand grain weight increased at normal sowing (31-42.8g) than late sowing (30-39.3). Three mutant lines (MASR99-11, MASR99-13, MASR99-64) had more 1000-grain weight than all checks under both sowings normal and late (40.3-42.8g and 38-39.3 respectively) (Tables 2 and 4). Grain yield of all genotypes significantly increased at normal sowing (2767-5563 kg/ha) than late (1467-4253 kg/ha). Six mutants (MASR99-06, MASR99-09, MASR99-11, MASR99-14, MASR99-15, MASR99-22) produced more yield than checks. At late sowing three mutants (MASR99-14, MASR99-22, MASR99-64) had shown increase in yield than Kiran-95 and Sarsabz, however, nine could produce higher yield than T.J-83 and Khirman (Tables 2 and 4). Taking overall mean grain yield at both sowing dates into consideration, four mutant lines showed minimum difference which confirmed that these genotypes could be less sensitive to heat stress; hence more suitable for late sowing (short duration).

Table 3. Yield components of wheat mutant lines under normal sowing (14-11-2005).

Mutant lines	Spike length (cm)	Spikelets/ Spike	Grains/ Spike	Main spike yield (g)
MASR99-01	11.8bcd	21.1abc	54abc	1.91ab
MASR99-03	11.2def	21.7abc	52abc	1.90ab
MASR99-06	12.5b	23.4a	60a	1.62ab
MASR99-07	11.3cde	22.4abc	58ab	1.84ab
MASR99-08	13.5a	20.3abc	56abc	2.09a
MASR99-09	11.3cde	22.0abc	56abc	2.13a
MASR99-11	12.0bcd	20.8abc	52abc	1.93ab
MASR99-12	10.4ijk	22.6abc	58a	1.64ab
MASR99-13	11.5cde	19.9bc	41e	1.55ab
MASR99-14	10.6hij	19.9bc	45bcd	1.83ab
MASR99-15	12.2bc	20.5abc	52abc	1.92ab
MASR99-16	11.0fgh	19.9bc	49abc	1.75ab
MASR99-17	10.8ghi	19.8c	42de	1.63ab
MASR99-18	11.1efg	20.1bc	49abc	1.76ab
MASR99-22	9.7bc	21.1abc	57ab	2.14a
MASR99-23	12.2efg	20.5abc	49abc	2.13a
MASR99-31	11.1bcd	21.7abc	44cde	1.35b
MASR99-37	12.1efg	21.5abc	44cde	1.49ab
MASR99-64	11.4bcd	22.0abc	52abc	2.11a
MASR99-70	11.4cde	23.0ab	57ab	1.76ab
MASR99-72	9.8jk	22.2abc	54abc	1.48ab
Sarsabz	12.1bcd	21.6abc	51abc	1.75ab
Kiran-95	10.7ghi	21.2abc	53abc	1.88ab
T.J-83	11.2def	21.2ab	57ab	1.96ab
Khirman	11.6cde	23.0 ab	52abc	1.53ab

Yield associated traits studied from 5 randomly selected plants showed wide variation at both sowing dates. Spike length ranged from 9.7 to 13.5cm at normal sowing condition whereas it reduced at certain extent (9.9-12.8cm) at late sown trial. Four mutants (MASR99-07, MASR99-17, MASR99-22, MASR99-70) had more spike length than check varieties (Tables 3 and 5). Similarly grains per spike had also shown significant reduction with delay in planting time (36.1-57.1) as compared to normal sowing (41-60). Non-significant difference was observed for spikelets per spike and main spike yield under both sowing dates. Five genotypes (MASR99-07, MASR99-08, MASR99-09, MASR99-14, MASR99-15) had more numbers of spikelets/spike than Sarsabz, Kiran-95 and T.J-83. Ten mutants (MASR99-03, MASR99-06, MASR99-07, MASR99-08, MASR99-11, MASR99-14, MASR99-15, MASR99-17, MASR99-23, MASR99-31) had more grains per spike than check varieties at late sowings. At normal sowing five mutant lines (MASR99-08, MASR99-09, MASR99-22, MASR99-23, MASR99-64) had more main spike yield and twelve lines had more main spike yield than check varieties at late sown trial (Tables 3 and 5). Mutant lines showed better performance under late sowing.

Table 4. Phenological and agronomic traits of wheat mutant lines under late sowing (23-12-2005).

Mutant lines	Days to heading	Days to maturity	Grain filling period	Plant height (cm)	1000-grain weight (g)	Grain yield (Kg/ha)
MASR99-01	75ef	119bcd	43bcd	98a	34.4efg	2150 efg
MASR99-03	72hi	113fg	42def	89c	34.3fg	3213 bcd
MASR99-06	77cd	121ab	44abc	81def	31.7hij	3890 bcd
MASR99-07	76e	118cde	42bcd	69j	30.8klm	1553 hi
MASR99-08	71i	110h	38hi	77gh	32.4hi	4037 bcd
MASR99-09	78c	120bc	41def	75ghi	32.5h	3247 bcd
MASR99-11	72hi	114f	42bcd	96b	39.3a	3710 bcd
MASR99-12	76e	116ef	40efg	82de	31.4ijk	3043 bcd
MASR99-13	72hi	110h	38hi	81de	35.3de	3760 bcd
MASR99-14	72hi	114fg	42cde	99a	35.8d	4380 bc
MASR99-15	71i	114fg	42bcd	83de	34.8efg	4050 bcd
MASR99-16	73g	120bc	47a	89c	30.5lm	2247 def
MASR99-17	73gh	114f	41def	80ef	31.7hij	3493 bcd
MASR99-18	71i	111gh	40abc	89c	33.8g	3893 bcd
MASR99-22	71i	116ef	45ab	88c	37.5bc	4667 b
MASR99-23	71i	116ef	45def	80ef	31.1jkl	3520 bcd
MASR99-31	82a	123a	41efg	81def	31.7hij	2017 fgh
MASR99-37	80b	119bc	39efg	89c	32.5h	2443 cde
MASR99-64	71i	116def	45ab	60 l	38.4b	4253 bcd
MASR99-70	76de	120bc	44abc	64 k	30.0m	1467 i
MASR99-72	72hi	111h	39ghi	96b	32.1hij	1800 ghi
Sarsabz	72hi	111gh	40efg	82de	35.2h	4240 bcd
Kiran-95	73gh	111gh	38i	78fg	38.1bc	4080 bcd
T.J-83	74fg	118cde	44bcd	83d	37.9bc	3517 bcd
Khirman	82a	121ab	39fgh	73i	37.3c	3223 bcd

Reduction percent of some important traits was calculated. Reduction in grain yield of all mutant lines was observed at late sowings when compared to normal sowing. MASR99-64 followed by MASR99-8, MASR99-14, MASR99-22 and Kiran-95 showed less (<20%) reduction in grain yield at late sowing. The results indicated that these genotypes possess better tolerance to heat stresses; could be suitable for late planting (Table 6). Reduction (0.3-17.5%) in 1000-grain weight was also observed in most of the mutants including check varieties at late planting. Some mutant lines (MASR99-3, MASR99-14 and MASR99-22) had shown contrary response for 1000-grain weight as it increased at late sowing. Eight mutants showed less than 4% reduction in 1000-grain weight; hence tolerant to high temperature stress for this trait (Table 6). Other important yield contributing traits such as plant height, maturity period, number of grains per spike and main spike yield had also been adversely affected due to delayed sowing.

Table 5. Yield components of wheat mutant lines under late sowing (23-12-2005).

Mutant lines	Spike length (cm)	Spikelets/ Spike	Grains/ Spike	Main spike yield (g)
MASR99-01	10.2fgh	19.4def	49.0bcd	1.86ab
MASR99-03	11.7abc	21.6abc	53.2abc	2.08ab
MASR99-06	11.0cde	21.6abc	53.7abc	1.70ab
MASR99-07	12.7ab	21.9abc	52.6abc	1.67ab
MASR99-08	10.9cde	23.1ab	52.1abc	1.92ab
MASR99-09	10.3efg	22.0abc	46.6ef	1.87ab
MASR99-11	10.4fgh	20.2cde	54.6abc	1.67ab
MASR99-12	10.2cde	20.1cde	43.1f	1.93ab
MASR99-13	10.9cde	20.3bcd	47.2def	1.84ab
MASR99-14	11.5bcde	21.9abc	55.4ab	1.95ab
MASR99-15	10.7def	22.9abc	57.1a	1.98ab
MASR99-16	11.5bcde	20.7bcd	49.8bcd	1.59ab
MASR99-17	12.0abc	21.4abc	52.9abc	1.70ab
MASR99-18	10.8cde	20.4bcd	48.2cde	1.70ab
MASR99-22	12.8a	17.8f	49.6bcd	1.95ab
MASR99-23	11.0cde	21.5abc	54.1abc	1.75ab
MASR99-31	9.9i	20.7bcd	53.7abc	1.83ab
MASR99-37	10.0hi	21.7abc	47.3def	1.84ab
MASR99-64	10.0ghi	19.3def	50.2bcd	1.55ab
MASR99-70	12.1abc	19.4def	49.7bcd	1.57ab
MASR99-72	11.3cde	19.1ef	47.2def	2.10a
Sarsabz	10.8cde	19.3def	49.7bcd	1.73ab
Kiran-95	11.4bcd	20.0cde	36.1g	1.44b
T.J-83	11.6abc	21.3abc	51.4abc	1.48ab
Khirman	11.5bcd	23.9a	46.6ef	1.71ab

Discussion

To get better crop yields, sowing time in terms of changed temperatures has been critical factor in various crops including wheat. The severe losses in grain yield have been observed with delay in planting time. Breeders are always interested to create genetic diversity among existing germplasm through incorporation of new and novel genes through conventional and mutation breeding techniques. Wheat is a self-pollinted crop therefore; there are enough possibilities to increase wheat yields through developing new high yielding varieties and by adoption of proper package of technology. Mutation and conventional plant breeding has made a significant progress in many plant species including wheat crop. Many high yielding wheat varieties have been developed throughout the world by using mutagenesis and conventional breeding. Newly evolved wheat mutant lines were therefore evaluated to determine the effects of sowing time and early and terminal heat stresses on grain yield and other related traits and to select lines suitable for various planting patterns viz., early, medium and late. In the present studies, it has been observed that grain yield, yield components and phenological traits were significantly reduced. Therefore, the higher grain yield could be achieved through normal sowing or by developing genotypes that could perform better in late sowing conditions. A mutant line MASR99-64 showed less reduction (11.8%) in grain yield at late sowings; could be suitable for late planting and possess heat tolerance. Other better genotypes identified were MASR99-8, MASR99-14 and MASR99-22. Five early maturing lines were also identified as compared to other genotypes which could be adjusted to various sowing patterns.

Table 6. Percent reduction in various yield and its associated traits of wheat mutant lines due to late plantings.

Mutant lines	Grain yield (Kg/ha)			1000-grain weight (g)			Plant height (cm)		
	Normal	Late	% Reduction	Normal	Late	% Reduction	Normal	Late	% Reduction
MASR99-01	3540	2150	-39.3	35.7	34.4	-3.6	82	98	19.5
MASR99-03	4223	3213	-23.9	33.5	34.3	2.4	106	89	-16.0
MASR99-06	5206	3890	-25.3	37.5	31.7	-15.5	97	81	-16.5
MASR99-07	2840	1553	-45.3	31.6	30.8	-2.5	86	69	-19.8
MASR99-08	4923	4037	-18.0	35.2	32.4	-8.0	96	77	-19.8
MASR99-09	5487	3247	-40.8	32.6	32.5	-0.3	104	75	-27.9
MASR99-11	5240	3710	-29.2	41.6	39.3	-5.5	108	96	-11.1
MASR99-12	4500	3043	-32.4	32.8	31.4	-4.3	106	82	-22.6
MASR99-13	5040	3760	-25.4	42.8	35.3	-17.5	109	81	-25.7
MASR99-14	5197	4380	-15.7	35.2	35.8	1.7	75	99	32.0
MASR99-15	5163	4050	-21.6	37.6	34.8	-7.4	95	83	-12.6
MASR99-16	4303	2247	-47.8	34.4	30.5	-11.3	111	89	-19.8
MASR99-17	4820	3493	-27.5	38.3	31.7	-17.2	103	80	-22.3
MASR99-18	4937	3893	-21.1	34.1	33.8	-0.9	104	89	-14.4
MASR99-22	5407	4667	-13.7	37.4	37.5	0.3	91	88	-3.3
MASR99-23	4767	3520	-26.2	35.8	31.1	-13.1	106	80	-24.5
MASR99-31	4373	2017	-53.9	35	31.7	-9.4	105	81	-22.9
MASR99-37	4717	2443	-48.2	35.2	32.5	-7.7	104	89	-14.4
MASR99-64	4820	4253	-11.8	40.3	38.4	-4.7	111	60	-45.9
MASR99-70	2767	1467	-47.0	31	30	-3.2	99	64	-35.4
MASR99-72	3333	1800	-46.0	33.3	32.1	-3.6	116	96	-17.2
Sarsabz	5563	4240	-23.8	38.2	35.2	-7.9	110	82	-25.5
Kiran-95	5037	4080	-19.0	39.4	38.1	-3.3	105	78	-25.7
T.J-83	4683	3517	-24.9	39.5	37.9	-4.1	79	83	5.1
Khirman	4957	3223	-35.0	38.2	37.3	-2.4	104	73	-29.8

Table 7. Percent reduction in various yield and its associated traits of wheat mutant lines due to late plantings.

Mutant lines	Maturity period (days)			Main spike yield (g)			No. of grains/spike		
	Normal	Late	% Reduction	Normal	Late	% Reduction	Normal	Late	% Reduction
MASR99-01	118	119	0.8	1.91	1.86	-2.6	54	49	-9.3
MASR99-03	116	113	-2.6	1.9	2.08	9.5	52	53.2	2.3
MASR99-06	116	121	4.3	1.62	1.7	4.9	60	53.7	-10.5
MASR99-07	114	118	3.5	1.84	1.67	-9.2	58	52.6	-9.3
MASR99-08	113	110	-2.7	2.09	1.92	-8.1	56	52.1	-7.0
MASR99-09	115	120	4.3	2.13	1.87	-12.2	56	46.6	-16.8
MASR99-11	114	114	0.0	1.93	1.67	-13.5	52	54.6	5.0
MASR99-12	123	116	-5.7	1.64	1.93	17.7	58	43.1	-25.7
MASR99-13	115	110	-4.3	1.55	1.84	18.7	41	47.2	15.1
MASR99-14	119	114	-4.2	1.83	1.95	6.6	45	55.4	23.1
MASR99-15	118	114	-3.4	1.92	1.98	3.1	52	57.1	9.8
MASR99-16	115	120	4.3	1.75	1.59	-9.1	49	49.8	1.6
MASR99-17	117	114	-2.6	1.63	1.7	4.3	42	52.9	26.0
MASR99-18	115	111	-3.5	1.76	1.7	-3.4	49	48.2	-1.6
MASR99-22	118	116	-1.7	2.14	1.95	-8.9	57	49.6	-13.0
MASR99-23	120	116	-3.3	2.13	1.75	-17.8	49	54.1	10.4
MASR99-31	120	123	2.5	1.35	1.83	35.6	44	53.7	22.0
MASR99-37	122	119	-2.5	1.49	1.84	23.5	44	47.3	7.5
MASR99-64	116	116	0.0	2.11	1.55	-26.5	52	50.2	-3.5
MASR99-70	115	120	4.3	1.76	1.57	-10.8	57	49.7	-12.8
MASR99-72	119	111	-6.7	1.48	2.1	41.9	54	47.2	-12.6
Sarsabz	119	111	-6.7	1.75	1.73	-1.1	51	49.7	-2.5
Kiran-95	120	111	-7.5	1.88	1.44	-23.4	53	36.1	-31.9
T.J-83	122	118	-3.3	1.96	1.48	-24.5	57	51.4	-9.8
Khirman	122	121	-0.8	1.53	1.71	11.8	52	46.6	-10.4

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