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Research Article

Comparative performance of cotton cultivars under conventional and ultra-narrow row (UNR) spacing

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Abstract
Maximum yield potential of a variety can be achieved by attaining optimum plant population per unit area. Among different agronomic practices, row spacing plays a key role in maintaining optimum plant population of cotton (*Gossypium hirsutum* L.) with improvement in its yield and quality. Two years field experiment was conducted at Bahauddin Zakariya University Multan, Pakistan to investigate the performance of four cotton cultivars *i.e.* NIAB-111, BH-160, MNH-786 and CIM-496 planted at ultra-narrow row (UNR, 30 cm) and conventional row spacing (75 cm). Experiment was laid out following randomized complete block design in factorial arrangement with three replications. Row spacing and cotton cultivars significantly affected the growth, yield and quality parameters except uniformity index. MNH-786 produced tallest plants and maximum number of squares, flowers, opened bolls per plant, average boll weight, and seed index ultimately increased seed cotton, cotton seed and lint yield.UNR spaced plants produced higher seed cotton, cotton seed and lint yield which seems to be the result of higher number of plants per unit area. Thus, it may be concluded that MNH-786 should be grown at 30 row spacing to get maximum yield.

Key words: Plant density; Inter-row spacing; Cultivars; Fiber length; *Gossypium hirsutum*.

Introduction
Cotton (*Gossypium hirsutum* L.) is one of the most important cash crops, playing a key role in the economic and social affairs of the world. It provides basic input to the textile industry [1], spindles and oil expelling units all over the world [2]. Presently, Pakistan ranks fourth among cotton producers in the world [3] and it accounts for 7% of value added in agriculture and 1.5% of GDP [4]. In Pakistan, cotton is cultivated on an area of 2.879 million hectares with a production of 13.026 million bales, which is tremendously lower than the yields obtained in other countries of the world. Among various factors responsible for low yield, the unavailability of improved varieties/ hybrids, [5] imbalanced fertilizer application [6] flare up insect pressure and sub optimal

or super optimal plant population density are the major ones [7, 8].

Cotton plant possesses a narrow range of ecological adaptability so the selection of crop variety in an agro-climatic region is of prime importance [9]. Cultivars vary considerably in seed cotton yield primarily due to different behavior in fruiting branches, productive bolls and seed cotton weight per boll [10, 11].Plant population density is directly related to intra- and inter-row spacing of plants, which not only influences crop yield and duration, but also its quality. Row spacing is more important in the establishment of an acceptable plant population for yield enhancement of cotton crop [12].

Traditionally cotton is planted in rows more than 76cm apart [13, 14] which increase growth duration and non-uniform branching. This may delay wheat sowing and ultimately cash crop competes with the food crop and poses a threat to food security of the country. Moreover, traditional plant spacing also results in higher production expenditures with compact crop prices.

Possible solution to reduce yield loses and improve plant population seems in the sowing of cotton in UNR spacing, which can produce greater seed cotton yield due to uniform branching, improved harvest efficiency, more yielding and short season cotton [15-19] as well as optimizing net profits [20, 21]. The larger number of cotton plants per unit area with fewer nodes concentrating their boll production in upper positions is the prominent feature in ultra-narrow row (UNR) systems of planting. Reduced branches of individual plant may decrease the production on one end, but it can be remunerated by additional plants per unit area on other end.

Therefore, keeping in view the different ecological conditions, importance should be given to the development of high yielding cotton cultivars. Owing to massive significance of cotton crop in the buildup of Pakistan's economy; scientists have made marvelous efforts to improve yield potential of the cotton crop under confined agro-ecological conditions. The present study was therefore executed with the objective to compare the productivity of cotton cultivars in order to evaluate the differences in growth, yield and quality by using UNR and conventional row spacing, under agro-climatic conditions of Multan.

Materials and Methods

Site description

The present studies were conducted to compare the performance of different cotton cultivars sown under conventional and UNR spacing at the Agronomic Research Area, Faculty of Agricultural Sciences and Technology, Bahauddin Zakariya University, Multan (Latitude 71.43^{o} E and Longitude 30.2^{o} N) on heavy clay loam soil during summer seasons of 2011 and 2012. Complete details of experimental site have been described earlier [22].

Experimental details

The experiment was laid out in randomize complete block design (RCBD) with factorial arrangement and performed in triplicate. Each experimental unit was of net plot size 3.75 × 6.10 m^2. The factors under study were comprised of four cotton cultivars viz., NIAB-111, BH-160, MNH-786, CIM-496 and two row spacing i.e., UNR (30cm) and conventional (75cm).

Crop husbandry

The experimental area was prepared after wheat harvesting with cultivator and beds were properly formed with a bed shaper. The cotton seeds of all the cultivars were dibbled manually on well moistened bedsduring1stweek of May 2011 and 2012. For the desired plant density gap filling and thinning was adopted on 10th and 22nd day after sowing, respectively. Nitrogen fertilizer was applied @ 125 kg ha^{-1}in the form of urea in three equal splits i.e. sowing, first irrigation and at peak flowering stage. The phosphorus and potassium fertilizers were applied @ 60:50 kgha^{-1}in the form of triple super phosphate and sulphate of potash, respectively, at the time of sowing. Irrigations were applied with good quality water and integrated pest management practices were adopted. All other agronomic practices were remained same for each treatment. The crops were harvested in the last week of October in both years. Data were recorded on number of plants m^{-2}, plant height (cm), number of leaves plant^{-1}, number of branches plant^{-1}, number of squares plant^{-1}, number of flowers plant^{-1}, number of opened bollsplant^{-1}, number of unopened bolls plant^{-1}, average boll weight (g), seed index (g), seed cotton yield (kg ha^{-1}), cotton seed yield (kg ha^{-1}), lint yield (kg ha^{-1}), lint index, gin out turn (5), fiber strength (g/tex), micronaire value, staple length (mm), uniformity index (%) and oil content (%).Seed cotton was handpicked twice in the middle two rows of each subplot in both years. The first picking started when the cotton bolls were about 60% open, and the second harvest was 20 days later in both years.

Meteorological Data

Meteorological data including daily temperature, relative humidity and rainfall, during the experiment period was collected from Agricultural Meteorological Cell of Central Cotton Research Institute, Multan, Pakistan, and monthly averages were computed (Table 1).Mean monthly temperatures for both experimental years were similar with less than 1.0°**C** differences, except during the months of July and November. July was 1.1°**C** warmer in 2011, while November was 2.0°**C** warmer in 2012. Experimental year 2012 was more humid as higher relative humidity was recorded for all months. More rainfall was recorded in 2011 (285.8mm) as compared to the year 2012 (277.3 mm).

Data collection and Statistical analysis

Data collected was subjected to analysis of variance (ANOVA) using the MSTAT software. Moreover, means of different treatments were compared by Duncan's Multiple Range Test (DMRT) at 5% level of significance [23].

Table 1. Mean temperature, mean relative humidity and total rainfall during crop growth cycle

Month/ Year	Mean monthly temperature (°C)		Mean monthly relative humidity (%)		Total monthly rainfall (mm)	
	2011	2012	2011	2012	2011	2012
May	33.4	32.6	38.0	55.8	16.8	4.5
June	33.4	34.0	44.9	61.2	7.8	0.10
July	32.4	33.5	56.8	66.6	56.6	28.9
August	31.5	31.8	66.5	74.1	70.4	18.3
September	29.0	29.4	74.0	83.6	134.2	218.7
October	26.2	25.3	67.6	72.5	0.0	6.8
November	18.0	20.0	60.7	84.1	0.0	0.0

Source: Agricultural Meteorology Cell, Central Cotton Research Institute, Multan, Pakistan.

Results

The success of a cropping system is critically based upon the cultivar selection, sowing time [24] as well as its planting at proper spacing. Spacing determines availability and interplant competition for plant growth resources like sun light interception, moisture and nutrients [25]. The comparison of cotton cultivar's performance under UNR and conventional row spacing showed that interaction between row spacing and cultivars significantly affected number of plants per unit area in both years. All the cultivars produced three times more number of plants per unit area under UNR spacing as compared to conventional spacing (Table. 1).

Average data of plant height significantly varied in response to row spacing and cotton genotypes significantly affected the average plant height in both experimental years (2011 and 2012). MNH-786 produced maximum height under UNR spacing and BH-160 produced minimum in conventional row spacing (Table. 1).The cotton cultivars exhibited significantly different number of branches plant^{-1}in both types of row spacing during 2011 and 2012. NIAB-111 produced highest number of branches plant^{-1}under conventional row spacing. Whereas, CIM-496 produced minimum branches plant^{-1}under narrow row spacing (Table. 1).In case of reproductive growth, cultivar MNH-786 produced maximum number of squares, flowers (Table. 1) and opened bolls plant^{-1}(Table. 2) under conventional row spacing. On the other hand, CIM-496 produced minimum number of flowers plant^{-1}under UNR spaced plants. Data from analysis of variance revealed that cotton cultivars and row spacing had significant effect on number of unopened bolls plant^{-1}.NIAB-111 showed largest number of unopened bolls plant^{-1}under conventional row spacing which was statistically at par with MNH-786 against the minimum in CIM-496 under UNR (Table. 2).Means of the data showed that MNH-786 produced highest average boll weight and seed index under conventional row spacing. Lowest average boll weight was recorded for CIM-496 under narrow row spacing (Table. 3). Similarly, minimum seed index was also observed for CIM- 496 (Table. 3). Final yield was the result of various yield contributing components. Cotton cultivar MNH-786 produced maximum seed cotton, cotton seed and lint yield under ultra-narrow row spacing while the minimum seed cotton and cotton seed yield was recorded forCIM-496 and lint yield for BH-160 under conventional row spacing (Table. 3).Gin out turn was significantly influenced by row spacing and cotton genotypes during both years. Under UNR spacing, CIM-496 produced maximum gin out turn against the minimum in NIAB-111 under conventional spacing (Table. 4).Cotton genotype NIAB-111 produced more fiber strength under conventional row spacing during both years. Least fiber strength was recorded for BH-160 under UNR spacing (Table. 4).Micronaire represents a combined measure of cotton fineness and maturity. Maximum micronaire was recorded for NIAB-111 during2011 and MNH-786 during succeeding year under conventional row spacing. Minimum micronaire was recorded for BH-160 under UNR spacing during both years (Table. 4). Under UNR spacing, NIAB-111 produced the maximum staple length during first year and CIM-496 in second year while, MNH-786 produced minimum staple length during both years under conventional row spacing (Table. 4). Cotton genotypes had statistically non-significant effect on uniformity index during both years. There was minute difference for uniformity index among different cotton genotypes and row spacing. However, under conventional spacing BH-160 produced maximum uniformity index during first year and CIM-496 during second year under UNR spacing (Table. 4)

Cotton genotypes and row spacing had significant effect on oil content. In both years cotton cultivar BH-160 produced maximum oil content under conventional row spacing. Minimum oil content was observed in cotton cultivar MNH-786 under UNR spacing (Table. 4).

Table 2. Effect of Row spacing on the growth and yield parameters of cotton genotypes

Treatment	No. of plants m^{-2}			Plant height (cm)			No. of squares $plant^{-1}$			No. of flowers $plant^{-1}$			No. of Branches $plant^{-1}$		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
R_1= 30 cm*	24.50 a	24.58 a	24.54a	80.69 a	80.36 a	80.53a	5.42 b	5.85 b	5.64b	2.31 b	3.14 b	2.73b	8.61 b	9.69 b	9.15 b
R_2= 75 cm	8.75 b	8.67 b	8.70 b	63.76 b	64.53 b	64.15 b	7.59 a	7.92 a	7.75a	3.73 a	4.47 a	4.10a	11.55 a	13.92 a	12.73a
LSD*	0.5477	0.4843	0.4890	3.5186	3.2494	3.3750	0.3720	0.3432	0.3009	0.1505	0.3014	0.2056	0.9309	0.8036	0.7327
V_1=NIAB-111	16.67	17.00	16.83	72.89 b	73.00 b	72.95 b	6.45 b	6.98 b	6.71 b	3.14 a	4.01 ab	3.57 a	11.61 a	12.64a	12.12 a
V_2=BH-160	16.50	16.33	16.42	67.07 c	67.41c	67.24 c	6.38 b	6.43 c	6.41 b	3.07 a	3.66 bc	3.37 a	7.68 b	11.15b	9.453 c
V_3=MNH-786	16.67	16.50	16.58	80.04 a	79.59 a	79.32 a	7.00 a	7.65a	7.33 a	3.24 a	4.17 a	3.71 a	10.66 a	12.20ab	11.43ab
V_4=CIM-496	16.67	16.67	16.67	69.90bc	69.78 bc	69.84 bc	6.19 b	6.46 c	6.33 b	2.70 b	3.40 c	3.05 b	10.38 a	11.22 b	10.77 b
LSD	ns	ns	ns	4.435	4.157	4.279	0.5297	0.4516	0.4051	0.1878	0.4533	0.2930	1.445	1.169	1.096
R_1x V_1	8.67 b	9.00 b	8.83 b	61.77 e	62.64 c	62.21 d	7.71 ab	8.10 b	7.91 b	4.01 a	4.71 a	4.36 a	13.07 a	14.96 a	14.01 a
R_1x V_2	8.67 b	8.33 b	8.50 b	60.08 e	60.85 c	60.47 d	7.20 b	7.26 c	7.23 c	3.75 a	4.34ab	4.05 a	9.30 c	13.29 ab	11.30cd
R_1x V_3	9.00 b	8.67 b	8.83 b	69.24cd	70.54 b	69.89 bc	8.11 a	8.94 a	8.53 a	3.85 a	4.93 a	4.39 a	12.28 ab	14.64 a	13.46ab
R_1x V_4	8.67 b	8.67 b	8.67 b	63.94de	64.09 c	64.02 cd	7.32 b	7.35 c	7.33 c	3.29 b	3.91bc	3.60 b	11.55 ab	12.78 b	12.16bc
R_2x V_1	24.67 a	25.00 a	24.83 a	84.02 a	83.36 a	83.69 a	5.19 cd	5.85 de	5.52 e	2.46 c	3.31cd	2.88 c	10.14 bc	10.32 c	10.23de
R_2x V_2	24.33 a	24.33 a	24.33 a	74.06bc	73.97 b	74.02 b	5.56 cd	5.61 e	5.58 de	2.40cd	2.97 d	2.69 c	6.06 d	9.15 c	7.61 f
R_2x V_3	24.33 a	24.33 a	24.33 a	88.85 a	88.63 a	88.74 a	5.89 c	6.35 d	6.12 d	2.23cd	3.42cd	2.83 c	9.04 c	9.77 c	9.41 e
R_2x V_4	24.67 a	24.67 a	24.67 a	75.85 b	75.47 b	75.66 b	5.06 d	5.57 e	5.32 e	2.12 d	2.89 d	2.51 c	9.21 c	9.53 c	9.37 e
LSD	1.185	1.072	1.071	6.272	5.879	6.051	0.7491	0.6387	0.5728	0.2656	0.6410	0.4144	2.043	1.653	1.550

*$R_1$and R_2 are row spacing of 30 and 75 cm, V_1 to V_4 are cotton cultivars, 2011 and 2012 are years

**Means with different letters are significantly different from each other (p< 0.05), while means with the same letters are not significantly different (p> 0.05). ns, implies that means are not significant.

Table 3. Effect of Row spacing on the yield parameters of cotton genotypes

Treatment	No. of opened bolls plant^{-1}			No. of unopened bolls plant^{-1}			Seed cotton yield (kg ha^{-1})			Cotton seed yield (kg ha^{-1})			Lint yield (kg ha^{-1})		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
R_1= 30 cm*	6.66 b	6.95b	6.80 b	2.17b	2.49b	2.33 b	3567.6a	3559.3a	3563.4a	2084.2a	2090.9a	2087.6a	1483.4 a	1468.3a	1477.7a
R_2= 75 cm	10.07a	9.67a	9.87a	3.68 a	3.63a	3.65 a	2896.1b	2962.7b	2929.4b	1761.1b	1813.1b	1787.1b	1134.9b	1149.6b	1142.3b
LSD	0.6333	0.6738	0.5559	0.2146	0.1763	0.1857	186.69	184.40	160.87	118.35	135.35	122.21	83.412	163.75	83.641
V_1=NIAB-111	8.129b	8.804	8.46ab	3.22 a	3.32 a	3.27 a	3237 b	3350 b	3293 b	1987 b	2039 b	2013 b	1249.8b	1311.1	1280 b
V_2=BH-160	8.325b	7.852	8.09 b	2.75 b	2.75 c	2.75 b	3123 b	3126 bc	3125 b	1905 b	1891 b	1898 b	1218.2b	1235.7	1231 b
V_3=MNH-786	9.665 a	8.672	9.17 a	3.08 a	3.20 a	3.14 a	3863. a	3646 a	3754 a	2289 a	2224 a	2256 a	1574.1 a	1421.8	1498 a
V_4=CIM-496	7.337c	7.901	7.62 b	2.64 b	2.97 b	2.81 b	2705 c	2922 c	2813 c	1511 c	1654 c	1582 c	1194.4b	1267.2	1231 b
LSD**	0.7713	ns	0.8129	0.2769	0.2145	0.2249	281.9	290.9	248.9	176.3	211.4	187.1	117.96	ns	132.1
R_1x V_1	9.56b	10.27a	9.91ab	4.095 a	4.00a	4.05 a	2952. c	3045cde	2999 de	1854 c	1922bcd	1888 bc	1098 c	1123 bc	1111c
R_1x V_2	9.60 b	9.09 a	9.35 b	9.600 b	3.16 c	3.24 b	2699 cd	2806 de	2752 ef	1681 c	1717de	1699 c	1018 c	1089 c	1053 c
R_1x V_3	11.96 a	10.03a	11.00 a	11.96 a	3.86 a	3.89 a	3569 b	3369 bc	3469 bc	2166 ab	2102abc	2134 ab	1402 b	1267abc	1335 b
R_1x V_4	9.16 b	9.27 a	9.21 b	9.161 b	3.51 b	3.43 b	2365 d	2631 e	2498 f	1343 d	1512 e	1427 d	1022 c	1120 bc	1071 c
R_2x V_1	6.70 c	7.34 b	7.02cd	2.340 c	2.65 d	2.49 c	3521 b	3655 ab	3588 b	2120 b	2156ab	2138 ab	1402 b	1499 ab	1450 b
R_2x V_2	7.05 c	6.61b	6.83cd	2.183 c	2.35 d	2.27 c	3547 b	3447 bc	3497 b	2128 b	2064abc	2096 ab	1419 b	1383 bc	1408 b
R_2x V_3	7.37 c	7.31 b	7.34 c	2.236 c	2.54 d	2.39 c	4157 a	3923 a	4040 a	2411 a	2347 a	2379 a	1746 a	1577 a	1661 a
R_2x V_4	5.51d	6.53b	6.02 d	1.923 c	2.44 d	2.18 c	3045 c	3212bcd	3128 cd	1678 c	1797cde	1737 c	1367 b	1415abd	1391 b
LSD	1.091	1.498	1.150	0.3916	0.3033	0.3181	398.7	411.4	352.0	249.3	298.9	264.6	182.5	364.9	186.8

*R_1 and R_2 are row spacings of 30 and 75 cm, V_1 to V_4 are cotton cultivars, 2011 and 2012 are years

**Means with different letters are significantly different from each other (p< 0.05), while means with the same letters are not significantly different (p> 0.05). ns, implies that means are not significant.

Table 4. Effect of Row spacing on yield and quality parameters of cotton genotypes

Treatment	Gin out turn (%)			Average boll weight (g)			Seed index (g)			Staple length (mm)			Uniformity index (%)		
	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean	2011	2012	Mean
R_1= 30 cm*	41.69a	41.29a	41.49a	2.79 b	2.94 b	2.86b	8.00 b	8.19 b	8.09 b	27.39	27.30	27.35	83.32	83.14	83.23
R_2= 75 cm	39.38b	38.84b	39.11b	3.47 a	3.53 a	3.50a	8.97 a	8.94 a	8.96a	27.29	27.20	27.24	83.03	82.98	83.00
LSD	0.9587	0.8079	0.8322	0.0640	0.1555	0.0870	0.1031	0.4107	0.2155	ns	ns	ns	ns	ns	ns
V_1=NIAB-111	38.53 c	38.20c	38.37c	3.18 b	3.15	3.17ab	8.65 b	8.478	8.56	28.43 a	27.97 a	28.20 a	83.45	82.97	83.21
V_2=BH-160	38.87c	38.49c	38.68c	3.09 c	3.26	3.18ab	8.35 c	8.60	8.47	27.90 a	27.69 a	27.79 a	83.23	83.11	83.17
V_3=MNH-786	40.67b	40.02b	40.34b	3.33 a	3.22	3.27a	8.80 a	8.42	8.61	25.17 b	25.40 b	25.28b	83.00	82.94	82.97
V_4=CIM-496	44.08a	43.58a	43.8a	2.92 d	3.30	3.11 b	8.15 d	8.75	8.45	27.87 a	27.94 a	27.90 a	83.02	83.21	83.11
LSD**	1.482	1.266	1.296	0.03916	ns	0.1238	0.1465	ns	ns	0.7199	0.7027	0.6657	ns	ns	ns
R_1x V_1	37.23f	36.83f	37.03f	3.60a	3.48a	3.53 a	9.10 ab	8.87ab	8.98a	28.40 a	27.91 a	28.16 a	83.17	82.83	83.00
R_1x V_2	37.70ef	37.21ef	37.46ef	3.45 b	3.56a	3.51 a	8.90 b	8.90 ab	8.90 a	27.80 a	27.67 a	27.73 a	83.77	83.10	83.43
R_1x V_3	39.33def	38.84de	39.08de	3.58 a	3.50a	3.54 a	9.30 a	8.88ab	9.09 a	25.23b	25.43 b	25.33 b	82.73	82.95	82.84
R_1x V_4	43.27ab	42.51b	42.89b	3.26c	3.58a	3.42 a	8.60c	9.11 a	8.85 a	27.73a	27.78 a	27.75 a	82.43	83.04	82.74
R_2x V_1	39.83cde	39.58cd	39.70cd	2.76 e	2.83b	2.80 c	8.20 d	8.09ab	8.15 b	28.47 a	28.04 a	28.25 a	83.73	83.10	83.42
R_2x V_2	40.03cd	39.76cd	39.90cd	2.74 e	2.95b	2.85bc	7.80 e	8.29ab	8.05 b	28.00a	27.71a	27.85 a	82.70	83.13	82.92
R_2x V_3	42.00bc	41.20bc	41.60bc	3.07d	2.94b	3.00b	8.30 d	7.97 b	8.13 b	25.10 b	25.37b	25.24 b	83.27	82.93	83.10
R_2x V_4	44.90a	44.64a	44.77a	2.60f	3.03b	2.81c	7.70 e	8.39ab	8.05b	28.00 a	28.10 a	28.05 a	83.60	83.38	83.49
LSD	2.096	1.791	1.8333	0.0554	0.3458	0.1751	0.2072	0.9116	0.4796	1.018	0.9937	0.9414	ns	ns	ns

*R_1 and R_2 are row spacings of 30 and 75 cm, V_1 to V_4 are cotton cultivars, 2011 and 2012 are years

**Means with different letters are significantly different from each other ($p< 0.05$), while means with the same letters are not significantly different ($p> 0.05$). ns, implies that means are not significant.

Discussion

Four cotton cultivars viz., NIAB-111, BH-160, MNH-786 and CIM-496 were assessed for their growth, yield and yield components performance at UNR and conventional row spacing. In UNR system of planting, more number of cotton plants per unit area having fewer nodes concentrating their boll production in upper positions produced fine quality and high yielding short season cotton **[15, 18, 19]**.

Cotton cultivars and plant spacing had significant effect on most of the growth, yield and quality parameters except uniformity index. Cotton cultivar MNH-786 remained consistent in high performance during both years. In UNR spacing (30 cm) more number of plants per unit area led to strong competition for light interception thereby increased the plant height and showed a negative association between plant height and row spacing **[26-28]**.Similarly, difference in cotton genotypes for plant height might be due to their genetic potential and plant's tendency to adjust itself according to available spacing **[18]**. The number of leaves plant^{-1}of each cultivar increased as rows spacing increased from 30 to 75 cm. Conventional row spacing produced more leaves which might be due to more number of branches and better circulation of solar energy in to plant's canopy **[25, 29, 30]**.

Number of branches plant^{-1}directly influences the final yield of cotton crop. Higher number of branches indicate the development of more fruiting points. NIAB-111 and MNH-786 produced higher number of branches under conventional row spacing. Narrow row spacing reduces the branches due to sever competition for nutrients, water and solar energy **[8, 31, 32]**.Cotton cultivar MNH-786 produced higher number of squares, flowers and bolls plant^{-1}might be due to their better genetic makeup as compared to other cultivars, efficient utilization of inputs and natural resources **[33]**. The higher number of opened bolls in MNH-786 and unopened bolls in NIAB-111 showed early and late maturing behavior of these cultivars, respectively. The other most probable reason might be that MNH-786 produced more number of branches, squares and flowers plant^{-1}which ultimately produced higher number of bolls, therefore, having more number of opened and unopened bolls plant^{-1}**[34]**.

The weight of boll and seed expresses the level of their development which is an important yield determinant and plays a vital role in exhibiting the yield potential of a crop. Conventional row spacing produced higher seed index and average boll weight as compared to UNR spacing. It might be due to less competition among plants for water, light and nutrients **[8]**. Similarly, among different cotton genotypes MNH-786 produced significantly higher seed index and average boll weight, which might be due to the genetic makeup for efficient utilization of inputs and natural resources.

Final yield is the reflection of the cumulative effect of various yield components which are differently affected by the growing conditions and crop management practices. Higher yield in UNR spacing was direct result of higher plant density as compared with conventional wider row spacing even having more number of bollsplant^{-1}. This higher plant density with narrow row spacing compensated the lesser number of bolls plant^{-1}and produced more of bolls per unit area**[8, 31]**. Likewise, among different cultivars MNH-786 produced higher seed cotton yield, cotton seed yield and lint yield both years which might be due to their superiority in genetic potential that finally warped into higher number of branches, squares, flowers, and bolls plant^{-1}with more weight **[34]**.

Gin out turn (GOT) is the lint to seed ratio calculated after ginning process. Row spacing significantly affected the gin out turn of cotton genotypes. Narrow row spacing and CIM-496 produced higher gin out turn as compared to wider spacing. Cotton fiber quality parameters differed significantly due to row spacing and genotypes. Fiber strength is an important trait in determining yarn spin ability, because weak fibers are difficult to handle during manufacturing process **[35]**. Fiber strength differed significantly due to differences among varieties **[11]**. The micronaire reading represents an arbitrary scale of relative values and does not directly evaluate any single physical fiber property **[35]**. It shows significant differences due to variation among different varieties **[11]**. Staple length is mainly affected by moisture contents and assimilation along with translocation of photosynthates from leaves to the productive parts of the plants. It is obvious from the results that cultivar and row spacing improved the staple lengths **[33, 36]**.

Cotton, though a fiber crop is an important source of edible oil in Pakistan. As rows spacing increased from 30 to 75 cm, the oil content increased, which showed the positive correlation with row spacing. It might be due to the effect of temperature during the physiological maturity.

Conclusion

The increases in yield of crops grown under UNR system were obtained through increased partitioning to fruit compared to the conventionally spaced crops. Higher yields were associated with a greater number of bolls per unit area and may be due to greater biomass production per unit area or increased partitioning to fruit. More bolls per unit area in UNR more than compensated for the associated smaller boll size. Genetic variation in cotton yield components and quality were observed. Using the ultra-narrow row spacing proved the maximum output with MNH-786, a dominant cultivar ability may lead to the better adaptation for the farmers and researchers in cotton yield.

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Authors' contributions

Envisioned the project and designed the experiment: H Nawaz & N Hussain, Acquired Funding: N Hussain, Performed Experiment: H Nawaz & M Arif, Analyzed the Data: H Nawaz, N Hussain, MIA Rehmani & A Yasmeen, Wrote the Paper: H Nawaz & MIA Rehmani, Reviewed and edited later version of draft: H Nawaz, N Hussain & MIA Rehmani

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