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Impact of Three Input Factors at Different Levels of Management on Yield Components and Yield of Basmati 385 Rice

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bstract

npact of three input factors such as plant density tillage profile and fertilizer were studied on farmer's field of Sadhoke, istrict Gujranwala during the year 1993 and 1994. The results of the experiments conducted both the years revealed that e mean highest grain yield of 4.95 t ha^{-1} was obtained when all the three input factors were adopted at recommended vels against 2.08 t ha^{-1} from farmer's level of inputs respectively. The highest mean contribution was due to fertilizer 1.23 ha^{-1} (42.4%) followed by plant density as 0.88 kgs ha^{-1} (29%) and tillage profile, 0.69 kgs ha^{-1} (21.9%). The mean ghest net return and benefit cost ratio of Rs. 8998 and 2.7 : 1 respectively were found from recommended or researcher's chnology whereas the minimum net return was of Rs. 711 from that of farmer's level of technology.

ntroduction

ice (*Oryza sativa* L) plays a dominant role in our national conomy. It is not only the staple food for more than half f the growing world population but also has emerged as an nportant export earning commodity during the recent ears. contributing 5.72 per cent to the national foreign xchange earnings (Pakistan Economic Survey, 1994-95). ice is grown on more than two million hectares i.e., about 0 percent of the total cultivated area. Because of special cological and soil conditions of rice growing tracts.
espite the prime position of rice in the economy of the ountry and in world rice market, the crop yields in Pakistan re discouragingly low being only 2.7 and 1.6 tons ha^{-1} for oarse and fine rice respectively (MINFA, 1993). It goes ithout saying that actual farmer yields of rice in the ountry are much lower than potential yield under farmer's onditions. A long list of factors responsible for this big gap nd the low yields in Punjab have been partially attributed o less per unit area plant population (Anonymous, 1980) nd the extent to which plant population affects the paddy ields has not been determined systematically so far. Similarly role of tillage profile and fertilizer in paddy yields s not well understood. Hence, in order to narrow the xisting gap, role of the input factors in question needs to e determined. The present study was therefore envisaged he following objectives:

1. Measure on farm yield gap.
2. Quantify the contribution of individual biological factors to the yield gap of rice crop.
3. Make economic evaluation of the contribution of input factors to determine the cost-benefit ratio as it involved in the adaptation of new farm technology.
4. Refine and develop site specific technology.

Materials and Methods

The research project to determine the contribution of Agronomic factors such as plant density, fertilizer and tillage profile in the yield gap was carried out under "out reach rice research programme" of Pakistan Agricultural Research Council in farmers field Sadhoke District Gujranwala during 1993 and 1994. The input levels for the agronomic factors were varied at two levels, one representing farmer's level
1,25000 hills /ha of management, the second representing the recommended OR researcher's level (5) of management. In this study, three factors plant density, fertilizer and tillage profile with two levels of management were organized in 3^2 factorial arrangement with randomized complete block design having a plot size of 6 x 8 m with three replications; the detail of treatments during 1993 and 1994 was as follows:

Treatment Combinations

Treatment		Plant density	fertilizer (F) (P)	Tillage Profile (T)
T1	P1F1A1	1	1	1
T2	P1F1A5	1	1	5
T3	P1F5A1	1	5	1
T4	P1F5A5	1	5	5
T5	P5F1A1	5	1	1
T6	P5F1A5	5	1	5
T7	P5F5A1	5	5	1
T8	P5F5A5	5	5	5

One seedling $hill^{-1}$ was transplanted with a row to row and plant to plant distance maintained at 20 x 20 cm in accordance with national recommendations. The missing hills (gaps) were replanted within a week after the mortality of transplanted seedlings had occurred. Two levels of NPK (kg ha^{-1}), farmer and recommended were applied in the form of urea single Super Phosphate and Potassium Sulphate Full doses of Phosphorus; Potash and 1/3rd of Nitrogen were applied at final operation for land preparation before ploughing and planking in wet conditions and incorporated in the soil. The second 1/3rd dose of nitrogen was applied at rapid filtering stage (30 DAT) whereas, the remaining $1/3^{rd}$ dose of nitrogen was top dressed at the time of panicle initiation (P1) stage (45 DAT).

Whereas all the agronomic practices other than under study were kept normal and uniform for all the treatments.

Standard procedures were followed to record observations on weed population (m^2), number of panicle bearing tillers (m^2), length of panicle (cm), number of spikelet per panicle, sterility percentage, 1000 grain weight (g) grain yield (t ha^{-1}) yield gap, contribution of each test factors, and marginal benefit cost ratio.

Data collected were statistically analysed by using the analysis of variance technique and differences among the treatments means were tested for significance by the Duncans New Multiple Range Test (Steel & Torrie, 1984).

Results and Discussion

Weed Population: Data pertaining to weed population (m^{-2}) are presented in Table 1. The application of recommended fertilizer (80-40-40-NPK kg ha^{-1}) to farmer's level of plant density established after farmer's level of land preparation resulted in significantly higher weed population (28, 33 plants m^{-2}) than other treatment combinations during 1993 and 1994 respectively. However, the application of recommended fertilizer to recommended plant density established after recommended level of land preparation significantly reduced the weed population (11, 13 m^{-2}) compared to that of treatment T6 where the recommended plant density was established after recommended level of land preparation and was treated with farmer's level (23-18-0 NPK kg ha^{-1}) of fertilization in both the years of study. The data further indicated that the recommended plant density in different treatment combinations suppressed weed population significantly over those treatment combinations where the crop was established at the farmer's level of plant density during 1993. In 1994 the effect of recommended plant density showed decreasing trend in weed population but it was statistically similar to those treatments where the plant density was established at farmer's level.

Table 1: Effect of Plant Density, Fertilizer and Tillage Profile under Different Levels of Management on Weed Population (m) ^{2} in Basmati-385 Rice

Treatments	1993	1994	Mean
T.1 : P1F1T1	22b	24ab	22.8b
T.2 : P1F1T5	17f	18b	17.7bcd
T.3 : P1F5T1	28a	33a	30a
T.4 : P1F5T5	20d	19b	19.5bcd
T.5 : P5F1T1	18c	21b	19.5bcd
T.6 : P5F1T5	14g	14b	13.8cd
T.7 : P5F5T1	20c	22b	21.3bc
T.8 : P5F5T5	11h	13b	11.8d

Means followed by a common letter are not significantly different at 5% level of probability by Duncan's Multiple Range Test.

Panicle bearing tillers: Maximum panicle bearing tillers (167 and 171 m^{2}) were obtained from treatment T8 where all the three input factors were adopted at recommended level during 1993 and 1994 respectively compared to minimum (118 and 120 m^{-2}) obtained from treatment T1 where all the three input factors were used at the farmer's level. Application of recommended fertilizer to farmer"s level of plant density established after farmer's level of land preparation resulted in significantly higher number of tillers than that recorded in treatment T1 where all the three input factors were adopted at farmer's level in both the years and in the mean data as well. The recommended plant density with farmer's level of fertilization produced significantly higher number of panicle bearing tillers over those treatments (T1, T2) where farmer's fertilizer was applied to farmer's plant density. Whereas, the recommended plant density with recommended level of fertilizer significantly increased the number of panicle bearing tillers over the treatments (T3, T4) where the recommended fertilizer was applied to farmer's level of plant density (13 plant m^{-2}) in both the years as well as for the mean data (Table-2). The crop established after the recommended level of land preparation in treatment T2 produced significantly higher number of panicle bearing tillers over the treatment (T1) where all the three inputs were used at farmer's level during 1993 and 1994 as well as for the mean data. Whereas, in the rest of the treatment combinations where the crop was established after recommended level of land preparation (Tillage profile) showed an increasing trend in the number of panicle bearing tillers over the treatments where plant density was established after farmer's level of land preparation in both the trial years. In case of pooled data, the trend observed of recommended level of land preparation over that of farmer's level of land preparation was similar to that observed in both the trial years but recommended level of land preparation in that treatment T8 where all the three input factors were adopted at recommended level produced significantly higher number of panicle bearing tillers over the treatment T7 where the crop was established after farmer's level of land preparation. These findings are in agreement with those of Razzaq *et al.* (1993) who stated that complete soil inversion technique was the best tillage practice in terms of tillering.

Table 2: Effect of Plant Density, Fertilizer and Tillage Profile under Different Levels of Management on No. of Panicle Bearing Tillers $(m)^{-2}$ in Basmati-385 Rice

Treatment	1993	1994	Mean
T.1 : P1F1T1	118f	120f	118f
T.2 : P1F1T5	134c	134c	134c
T.3 : P1F1T1	141de	143de	141d
T.4 : P1F1T5	145cd	148cd	145d
T.5 : P5F1T1	152bc	157bc	152c
T.6 : P5F1T5	156b	161ab	156bc
T.7 : P5F1T1	159ab	162ab	159b
T.8 : P5F1T5	167a	171a	167a

Means followed by a common letter are not significantly different at 5% level of probability by Duncan's Multiple Range Test.

Length of Panicle: Maximum increase (31.4 and 31.5 cm) in panicle length resulted from treatment T8 where all three input factors were used at recommended level, compared to minimum (26.6 and 26.5 cm) recorded in reatment where farmer's level of fertilizer was applied to ecommended plant density transplanted after farmer's level of land preparation during 1993 and 1994 respectively as vell as in two years mean data. But it (T8) was statistically imilar to treatments T4 and T7 where recommended ertilizer was applied to farmer's plant density transplanted fter recommended level of land preparation or where ecommended level of fertilizer was applied to ecommended plant density established after farmers level of land preparation during both the trial years and in the nean data as well. In the pooled data however, the ecommended level of land preparation resulted in ignificantly higher panicle length than the treatment ombinations where the farmer's level of land preparation vas adopted before transplanting.

able 3: Effect of Plant Density, Fertilizer and Tillage Profile under Different Levels of Management on Length of Panicle (cm) in Basmati-385 Rice

reatment	1993	1994	Mean
.1 : P1F1T1	28.13dc	26.5c	27.33d
.2 : P1F1T5	29.13cd	28.3cd	28.72bc
.3 : P1F5T1	29.47bc	29.47bc	29.47b
.4 : P1F5T5	30.50ab	30.77ab	30.64a
.5 : P5F1T1	26.60f	27.50c	27.55d
.6 : P5F1T5	27.50ef	27.8de	27.65cd
.7 : P5F5T1	30.90a	30.7ab	30.80a
.8 : P5F5T5	31.40a	31.5a	31.45a

Aeans followed by a common letter are not significantly different t 5% level of probability by Duncan's Multiple Range Test.

Spikelets Panicle ^{1}: It is evident from the data that pplication of recommended fertilizer to recommended plant lensity established after recommended level of land preparation recorded the higher number of spikelets panicle (143 and 146) in 1993 and 1994, respectively compared o the lowest number of spikelets (109 and 111) obtained rom the treatment (T5) where the recommended plant lensity was established after farmer's level of land preparation (Tillage profile) and was treated with farmers evel of fertilization. The data further indicated that pplication of recommended fertilizer to farmer's plant lensity established either after recommended or farmer's evel of land preparation produced significantly higher number of spikelets than the treatment (T1) where all the hree input factors were adopted at farmers level. Application of farmer's fertilizer to either recommended or armer's level of land preparation resulted in statistically similar number of spikelets panicle^{-1} to those treatment (T1, T2) where farmer's fertilizer was applied to farmer's plant lensity established either after farmer's or recommended evel of land preparation in both the trial years and in the nean data. The recommended plant density treated with ecommended level of fertilizer and established after ecommended land preparation resulted in significantly nigher number of spikelets panicle^{-1} than those got in reatment T3, T4 and T7 where farmer's plant density was reated with recommended fertilizer and was established either after farmer or recommended level of land preparation or where the recommended plant density was treated with ecommended fertilizer and established after farmer's level of land preparation in both the years. Application of ecommended fertilizer to farmer's plant density that was established after farmer's level of land preparation failed to exhibit significant effect on spikelets panicle^{-1} compared to treatment T6 where recommended plant density was treated with farmer's fertilizer and established after recommended level of land preparation. The recommended level of land preparation in treatment T8 where all the three input factors were adopted at the recommended level significantly contributed in spikelets panicle^{-1} compared to treatment (T7) where the ;recommended plant density was established after farmer's level of land preparation during both the years of experimentation. The perusal of mean data also showed a similar increase in spikelets panicle^{-1} as observed in 1993 and 1994 (Table-4). Razzaq *et al.* (1993) support the findings by stating that complete soil inversion technique was the best tillage in terms of grains per panicle.

Table 4: Effect of Plant Density, Fertilizer and Tillage Profile under Different Levels of Management on Spikelets Panicle ^{1} in Basmati-385 Rice

Treatments	1993	1994	Mean
T.1 : P1F1T1	113ef	115ef	114e
T.2 : P1F1T5	118de	121de	120d
T.3 : P1F5T1	125cd	127cd	126c
T.4 : P1F5T5	134b	136b	135b
T.5 : P5F1T1	109f	111f	110e
T.6 : P5F1T5	124cd	126cd	125c
T.7 : P5F5T1	131bc	134bc	133b
T.8 : P5F5T5	143a	146a	145a

Means followed by a common letter are not significantly different at 5% level of probability by Duncan's Multiple Range Test.

Sterility (%): Minimum sterility (3.5 and 3.9%) was recorded from the treatment where the farmer's level of plant density was established after recommended level of land preparation and was treated with farmer's level of fertilizer during 1993 and 1994 respectively against maximum sterility (7.6 and 8.1%) obtained from the treatment (T3) where recommended fertilizer was applied to farmer's plant density established after farmer's level of land preparation. The sterility also decreased significantly with the adoption of three levels of input factors at the recommended levels over the treatment (T3) where recommended fertilizer was applied to farmer's plant density established after farmer's level of land preparation. The two years mean data also followed similar trend as observed in 1993 and 1994. These findings are in

Table 5: Effect of Plant Density, Fertilizer and Tillage Profile under Different Levels of Management on Sterility (%) in Basmati-385 Rice

Treatments	1993	1994	Mean
T.1 : P1F1T1	5.3b	5.8bc	5.5bc
T.2 : P1F1T5	3.5b	3.9c	3.7d
T.3 : P1F5T1	7.6a	8.1a	7.9a
T.4 : P1F5T5	5.3b	5.2bc	5.2bcd
T.5 : P5F1T1	4.7b	6.0bc	5.3bcd
T.6 : P5F1T5	3.9b	4.0c	3.9cd
T.7 : P5F5T1	5.2b	6.4ab	5.77b
T.8 : P5F5T5	3.8b	4.3bc	4.1bcd

Means followed by a common letter are not significantly different at 5% level of probability by Duncan's Multiple Range Test.

conformity with those of Wakamatsu (1994) who stated that the ripening percentage of grains decreased by increasing the N rate.

1000-Gran Weight (g): It is evident from the data given in Table-6 that application of recommended fertilizer (80-40-40 NPK kg ha^{-1}) to farmers plant density (13-plants m^{-2}) established after farmers level of land preparation produced significantly higher 1000-grain weight than the treatments (T1, T2) where either all the three input factors were adopted at farmer's level or where the farmer's plant density was established after recommended level of land preparation during both the years, and also in the mean data. Application of recommended fertilizer to farmer's level of plant density transplanted after recommended level of land preparation resulted in statistically similar grain weight compared to that noted in treatment T8 where all the input factors were used at the recommended level. The recommended plant density treated with farmer'' level of fertilizer and established after farmer'' level of land preparation also produced non-significant differences in the grain weight compared to treatment T1 where all the three input factors were adopted at farmer's level. Among various treatments, the heavier grain weight (24.0 and 24.1 g) was recorded from the treatment where all the three input factors were adopted at recommended level against the lower grain weight (19.8 and 19.9 g) obtained from the treatments (T5, T1) where farmers fertilizer was applied to recommended plant density transplanted after farmers level of land preparation or where all the three input factors were used at farmer's level of management during 1993 and 1994 respectively. The recommended level of land preparation for the establishment of farmer's plant density treated with recommended level of fertilizer produced significantly higher 1000-grain weight than treatment T3 where the farmers plant density was transplanted after the farmer's level of land preparation in both the years and for the mean two years data. Moreover, farmer's level of land preparation in treatment T7 where recommended level of fertilizer was applied to recommended plant density significantly reduced the 1000-grain weight than treatment T8 where all the three input factors were adopted at recommended level during both the years of experimentation. The results are in agreement with those of Ali *et al.* (1992) who stated that complete puddling gave the highest grain weight whereas, the dry land preparation gave the lowest grain weight. The findings are also in conformity with those obtained by Karim *et al.* (1993) who stated that, 1000-grain weight decreased with increasing plant density.

7.a.Paddy Yield: The treatment (T8) where all the three input factors were adopted at the recommended level produced significantly higher grain yield (4.89 and 5.01 t ha^{-1}) than rest of the treatments under study during 1993 and 1994 respectively, as well as in the mean data of both the years. The lowest yield of 2.05 tons ha^{-1} was recorded from treatment T1 where all the three input factors were adopted at farmer's level of inputs. Application of recommended fertilizer (80-40-40 NPK kg ha^{-1}) produced significantly higher paddy yield than the treatments (T1, T2, T5 and T6) where farmer's level of fertilizer was applied in different treatment combinations. Application of recommended fertilizer in treatment T8 where all the inputs were used at recommended level also produced significantly higher paddy yield than treatment T6 where the recommended plant density was established after recommended level of land preparation and was treated with farmer's level of fertilization. The recommended plant density treated with farmer's level of fertilizer and established after farmer's level of land preparation produced significantly higher paddy yield than the treatment T1 where all the three input factors were adopted at farmers level during both the years. The recommended plant density treated with recommended fertilizer and established after farmer's level of land preparation resulted in significantly higher paddy yield than treatment T3 where farmer's plant density was treated with recommended level of fertilizer and was established after farmer's level of land preparation. The recommended plant density in treatment T8 where all the three input factors were adopted at recommended level produced significantly higher paddy yield than treatment T4 where farmer's plant density was established after recommended level of land preparation and was treated with recommended level of fertilization. The establishment of either recommended or farmer's plant density after recommended level of land preparation produced significantly higher paddy yield than the treatments (T1, T3, T5 and T7) where the crop was established after farmer's level of land preparation during both the trial years. The findings are in agreement with those of Razzaq *et al.* (1993)

Table 6: Effect of Plant Density, Fertilizer and Tillage Profile under Different Levels of Management on 1000-Grain Weight (gms) in Basmati-385 Rice

Treatments	1993	1994	Mean
T.1 : P1F1T1	20.2d	19.9e	20.05c
T.2 : P1F1T5	20.3d	20.3de	20.30c
T.3 : P1F5T1	23.0c	22.1c	22.55b
T.4 : P1F5T5	23.6ab	23.7ab	23.65a
T.5 : P5F1T1	19.8d	20.2e	20.00c
T.6 : P5F1T5	20.2d	20.7d	20.45c
T.7 : P5F5T1	23.2bc	23.4b	23.30a
T.8 : P5F5T5	24.0a	24.1a	24.05a

Means followed by a common letter are not significantly different at 5 % level of probability by Duncan's Multiple Range Test.

Table 7a: Effect of Plant Density, Fertilizer and Tillage Profile under different Levels of Management on Paddy Yield (t ha^{-1}) in Basmati-385 Rice

Treatments	1993	1994	Mean
T.1 : P1F1T1	2.05h	2.11l	2.08h
T.2 : P1F1T5	2.76g	2.83c	2.80g
T.3 : P1F5T1	3.28c	3.53c	3.41c
T.4 : P1F5T5	3.86c	4.08b	3.97c
T.5 : P5F1T1	2.97f	3.05d	3.01f
T.6 : P5F1T5	3.65d	3.70c	3.68d
T.7 : P5F5T1	4.04b	4.21b	4.13b
T.8 : P5F5T5	4.89a	5.01a	4.95a

Means followed by a common letter are not significantly different at 5% level of probability by Duncan's Multiple Range Test.

le 7b: Yield Gap and Additional Contribution of Improved Technology Over Farmer's Level of different Agronomic Factors during 1993-1994

el of hnology	Year of Trial	Farmer Input Level	Recommended input Level	Gap t-ha^{-1}	Plant Density	Fertilizer	Tillage Profile	Resi-dual
ommended vs ner's Technology	1993	2.05	4.89	2.84	0.9	1.16	0.7	0.08
ent				(138.5)	(30)	(40.6)	(22.7)	(2.9)
ommended vs ner's Technology	1994	2.11	5.01	2.9	0.85	1.29	0.68	0.08
ent				(137.4)	(27)	(44)	(21)	(2.8)

le 7c.

Level of Technology	Total variables cost (excluding land rent (Rs. ha^{-1})	Additional cost (Rs. ha^{-1})	Gross return of technology (Rs. ha^{-1})	Return above variable cost (RAVC) (Rs. ha^{-1})	Additional revenue of technology (Rs. ha^{-1})	Marginal Benefit cost ratio (MBCR)
			KHARIF - 1993			
Farmer's Technology	8810	--	9841	1031	--	--
Recommended Technology	13222	4412	22737	9515	8484	2.9 : 1
			KHARIF - 1994			
Farmer's Technology	10111	--	10527	416	--	--
Recommended Technology	15450	5339	24042	8592	8176	2.5 : 1

: Except the three input factors the rest cultural and plant protection measures were constant for the three different nological levels.

stated that complete soil inversion technique was the tillage practice in terms of grain weight and paddy . Ali *et al.* (1992) also supported the findings by stating complete puddling gave the highest grain yield. bani *et al.* (1990) also concluded that the crop rmed best under wet tillage and least under zero e.

Yield Gap and Contribution of Input Factors to Yield Yield gap is the difference between potential yield and obtained with farmer's level of inputs. The yield gap g 1993 was 2.84 t-ha^{-1} (138.5%) while 2.9 t-ha^{-1} .4%) yield gap was obtained during 1994. The mean gap of 2.8 t-ha^{-1} resulted from both the years (Table

e study of recommended vs farmer's level of ology about three input factors i.e., plant density, zer and level of land preparation (Tillage profile). The (Table 7) indicated that the farmer's level of fertilizer the biggest constraint to high yield of rice. The ibution in paddy yield due to recommended fertilizer 1.16 t-ha^{-1} (40.6%) and 1.29 t-ha^{-1} (44%) during and 1994 respectively while recommended plant ty on, an average contributed 0.9 t-ha^{-1} (30%) and t-ha^{-1} (27%) during both the respective years. The mended level of land preparation (Tillage profile) contributed 0.7 t-ha^{-1}) (22.7%) and 0.68 t-ha^{-1} (21%) to paddy yield in 1993 and 1994 respectively. The contribution of the residual to paddy yield other than input factors was estimated to be 0.08 t-ha^{-1} (2.9%) and 0.08 t-ha^{-1} (2.8%) of total yield gap during 1993 and 1994 respectively. These findings are in agreement with those of Zia *et al.* (1987) and Ali *et al.* (1985) who reported that recommended level of land preparation contributed 22.6 and 23 per cent more than farmer's level in IR.6 rice in Punjab and Sindh respectively.

7.c. Economic Evaluation: The data given in Table 7-c revealed that the return above variable costs of farmer's level of technology was found to be Rs. 1031 per hectare of rice during Kharif 1993. It was known that the recommended technology showed an increased revenue at the rate of Rs. 8484 ha^{-1} of rice after spending an increased cost of Rs. 4412 ha^{-1}. Thus the recommended technology, on an average yielded net return at the rate of Rs. 9515 ha^{-1} of rice and benefit cost (BC) ratio in the proportion of 2.9: 1 was achieved during 1993. The said technology during Kharif 1994 yielded an additional revenue of Rs. 8176 ha^{-1} over farmers technology after spending an additional cost of Rs. 5339 ha^{-1}. Thus the recommended technology yielded net returns at the rate of Rs.8592 ha^{-1}) of rice and B:C ratio in the proportion of 2.5:1.

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