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Contribution and impact of production factors on growth, yield attributes, yield and economics of rainfed wheat (*Triticum aestivum*)

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ABSTRACT

A field experiment was conducted during the winter (*rabi*) season of 1996–97 to 1998–99 to find out the contribution of different production factors on grain yield of wheat (*Triticum aestivum* L. emend. Fiori & Paol.) and preferential order of input supply under resource constraint conditions. Complete package of practices resulted in significantly higher mean grain yield (3, 021 kg/ha) and net returns (Rs 7,797/ha) compared with the grain yield (1,497 kg/ha) and net returns (Rs 1,670/ha) obtained under farmer's practice. Inclusion of recommended fertilizers, weed management and variety separately in farmers' practice resulted in significantly higher mean grain yield (41.9, 36.3 and 24.2%) and net returns (Rs 5,522, 2,835 and 2,732/ha respectively) than farmers's practice. However, inclusion of line sowing in farmers' practice showed net loss of Rs 339 /ha compared to farmers' practice. Grain yield decreased significantly when either of the production factors was withdrawn from complete package of practices and the maximum reduction in mean grain yield was recorded due to fertilizers (42.2%), followed by weed management (34.9%), variety (30.8%), timely sowing (17.4%), line sowing (9.1%) and plant-protection measures (8.2%). Net returns also reduced significantly when either improved variety or recommended fertilizers or weed management or timely sowing was withdrawn from complete package of practices. However, exclusion of line sowing or plant-protection measures from complete package of practices did not bring significant reduction in net returns compared to complete package of practices.

Key words : Wheat, Production factor, Yield, Economics, Rainfed

Wheat is the most important winter (*rabi*) crop in Uttaranchal state. Of the total area under wheat, rainfed wheat accounts for more than 90%. The low productivity of rainfed wheat in the state (1,623 kg/ha) as against national average (2, 750 kg/ha) is mainly attributed to growing of local varieties under low input use. Due to poor purchasing power, farmers of state in general, do not follow complete package of prac-

tices in wheat cultivation. Keeping above facts in view, the present investigation was therefore, carried out to find out contribution of different production factors on yield and preferential order of input supply under resource constraint conditions.

MATERIALS AND METHODS

The field experiment was conducted during the winter (*rabi*) season of 1996–97, 1997–98 and 1998–99 at experimental farm, Hawalbagh of Vivekananda Parvatiya Krishi Anusandhan Sansthan (ICAR), Almora, under rainfed condition. The soil of experimental site was sandy loam, slight acidic in reaction (6.0 pH), low in available N, medium in available P and K. The experiment consisting 13 treatments was laid out in randomized block design with 3 replications. The treatments were: T_1, farmers' practice (FP); T_2 , FP + improved variety ('VL Gehun 738'); T_3 , FP+ recommended fertilizers (40 kg N/ha and 20 kg P_2O_5/ha); T_4, FP + recommended weed management (2 hand-weedings); T_5, FP + line sowing (23 cm apart); T_6, FP + plant-protection measures (seed treatment with Vitavex @ 2.5 g/kg seeds and foliar spray of Dithane M-45, 0.25% solution); T_7, complete package of practices (CPP); T_8, CPP—improved variety ('Local' variety); T_9, CPP—fertilizers; T_{10}, CPP—weed management; T_{11}, CPP—line sowing (broadcast sowing); T_{12}, CPP—plant-protection measures; and T_{13}, CPP—timely sowing (15 days delay sowing). Famers' practice includes broadcast sowing of untreated seeds of local variety @ 125 kg/ha, application of partially decomposed compost (10 tonnes/ha) and 1 manual weeding (February end/March). Complete package of practices includes line sowing (23 cm apart) of treated seeds (Vitavex @ 2.5 g/kg seeds) of improved variety ('VL Gehun 738') @ 100 kg/ha, recommended fertilizers (60 kg N, 30 kg P_2O_5 and 20 kg K_2O/ha), weed management (2 hand-weedings) and foliar spray of Dithane M-45, 0.25% solution. Crop was sown on 15, 20 and 16 October during 1996–97, 1997–98 and 1998–99 respectively. Half the N and full P and K fertilizers were applied at sowing. Remaining N was top-dressed on the occurrence of good rains during January end–February. The required amount of N, P and K nutrients was supplied through urea, single superphosphate and muriate of potash respectively. Soil samples at 0–15 cm depth were taken before sowing. Hundred gram soil in aluminum moisture box was kept in hot-air oven at 100 ± 1°C to till constant weight. Thereafter dried samples were weighed and moisture(%) was recorded. Soil-moisture availability at sowing was sufficient for seed germination, being 17.5, 16.1 and 15.9% (w/w) during crop season of 1996–97, 1997–98 and 1998–99 respectively. Climate of mid-hills of N–W Himalayas is sub-temperate characterized by moderate summers with well-distributed rainfall and congenial for wheat cultivation. Crop received 244.3, 328.5 and 205.6 mm total rainfall in 31, 40 and 20 rainy days during crop season of 1996–97, 1997–98 and 1998–99 respectively. The weekly mean range of maximum and minimum temperature during 1996–97, 1997–98 and 1998–99 was 12.3–29.3, 16.4–32.3 and 16.3–35.3°C and –0.7–12.0, –1.5–13.5, –1.7–14.9°C, respectively.

RESULTS AND DISCUSSION

Growth and yield attributes

More plant height and effective tillers/m^2 were recorded during 1997–98 than 1996–97 and 1998–99 and during 1998–99 than 1996–97 which was attributed to variations in rainfall occurred during vegetative phase of the crop, particularly at tillering stage in different years (Table 1). Crop sown during 1996–97 received 61.0 mm rainfall only (5.5 mm in October and 55.5 mm in January second fortnight) compared with 136.1 mm (9.8 mm in October, 51.7 mm in November, 69.9 mm in December and 4.7 mm in January) during 1997–98 and 162.7 mm (108.5 mm in October, 5.0 mm in November and 49.2 mm in January) during 1998–99, after sowing to January. However, other yield attributes, viz spike length, spikelets/spike, grains/spike and 1,000-grain weight, were superior in the crop sown during 1996–97 and 1997–98 than 1998–99, which was attributed to more and better distribution of rainfall prior to and during reproductive phase of the crop in different years. Crop sown during 1996–97

Table 1. Effect of production factors on growth and yield attributes of rainfed wheat

Treatment	Plant height (cm)				Effective tillers/ m^2				Spike length (cm)			
	Y_1	Y_2	Y_3	Pooled	Y_1	Y_2	Y_3	Pooled	Y_1	Y_2	Y_3	Pooled
T_1	90.7	135.4	120.9	115.7	290	369	320	326	7.4	7.7	6.8	7.3
T_2	80.2	115.8	98.7	98.2	200	232	216	216	8.8	9.2	8.6	8.8
T_3	95.6	143.7	130.2	123.2	323	409	370	366	8.0	8.3	7.4	7.9
T_4	93.7	137.3	128.4	119.8	316	399	358	358	7.8	8.1	7.2	7.7
T_5	93.0	136.0	122.8	117.3	300	374	332	335	7.6	7.8	7.0	7.5
T_6	93.6	135.5	123.0	117.4	302	388	348	346	7.5	7.8	7.0	7.4
T_7	84.6	118.8	105.7	103.0	220	252	248	240	9.6	9.9	9.4	9.3
T_8	95.8	145.4	130.6	123.9	282	360	310	317	7.8	8.6	7.6	8.1
T_9	80.7	112.7	99.4	97.6	186	220	214	207	8.8	9.3	8.7	8.9
T_{10}	83.7	112.5	99.3	98.5	190	226	220	212	8.9	9.3	8.8	9.0
T_{11}	80.0	116.3	103.9	100.1	178	240	230	217	.94	9.8	9.3	9.5
T_{12}	83.6	116.8	104.1	101.5	212	238	232	227	9.4	9.7	9.3	9.5
T_{13}	80.6	117.8	102.6	100.4	210	240	232	227	9.3	9.4	8.8	9.2
CD (P = 0.05)	7.4	5.9	6.2	4.3	29	24	27	21	0.6	0.5	0.5	0.4

Table 1. *Continued*

Treatment	Spikelets/spike				Grains/spike				1,000-grain weight (g)			
	Y_1	Y_2	Y_3	Pooled	Y_1	Y_2	Y_3	Pooled	Y_1	Y_2	Y_3	Pooled
T_1	15.7	16.0	15.1	15.6	36.6	36.9	24.9	36.1	34.8	33.5	31.8	33.3
T_2	17.1	17.7	16.5	17.1	41.2	42.1	40.7	41.3	41.8	44.6	36.0	40.8
T_3	16.8	17.0	16.0	16.6	38.1	38.5	36.8	37.8	35.6	34.1	32.9	34.2
T_4	16.7	16.9	15.9	16.5	37.6	38.1	36.4	37.4	35.3	33.9	32.2	33.8
T_5	16.1	16.2	15.4	15.9	36.8	37.1	35.5	36.5	34.8	33.7	32.0	33.5
T_6	16.2	16.4	15.4	16.0	37.0	37.3	35.6	36.6	34.9	33.9	31.7	33.5
T_7	18.5	18.9	17.8	18.4	44.9	47.2	46.0	46.0	42.4	46.0	36.5	41.6
T_8	16.9	17.4	16.1	16.8	38.6	39.9	36.8	38.3	35.8	34.3	31.7	33.9
T_9	16.9	17.6	16.5	17.0	42.8	44.0	40.9	42.5	39.4	44.1	35.7	39.7
T_{10}	17.1	17.8	16.4	17.1	44.0	44.0	41.5	43.1	40.2	44.6	36.0	40.3
T_{11}	18.0	18.4	17.6	18.0	45.7	47.6	44.7	46.0	41.6	45.8	36.4	41.2
T_{12}	18.2	18.2	17.6	18.0	46.2	47.0	44.8	46.0	41.4	45.6	36.5	41.2
T_{13}	17.4	17.8	16.4	17.2	44.6	45.1	42.8	44.2	40.1	43.4	34.0	39.2
CD (P=0.05)	1.5	1.4	1.7	1.2	2.6	2.8	3.0	1.9	2.2	1.6	1.8	1.1

T_1, Farmers' practice (FP); T_2, FP + improved variety; T_3, FP + recommended fertilizers; T_4, FP+ recommended weed management; T_5, FP+ line sowing; T_6, FP + plant-protection measures; T_7, complete package of practices (CPP); T_8, CPP—improved variety; T_9, CPP—fertilizers; T_{10}, CPP—weed management; T_{11}, CPP—line sowing; T_{12}, CPP—plant-protection measures; T_{13}, CPP—timely sowing

Y_1, 1996–97; Y_2, 1997–98; Y_3, 1998–99

and 1997–98 received 135.1 mm (in February 11.2 mm, March in 30.8 mm and in April 93.1 mm) and 187.2 mm (in February 47.2 mm, in March 82.2 mm in April and 58.0 mm) rainfall, respectively, as compared with 11.4 mm rainfall (February only) during 1998–99.

Growth and yield attributes were affected significantly due to different production factors (Table 1). Plant height and effective tillers/m^2 were significantly higher under farmers' practice compared with complete package of practices. However, reverse was true for spike length, spikelets/spike, grains/spike and 1,000-grain weight. Small seed size of 'Local' variety coupled with its higher seed rate (125 kg/ha) as against bold seed size and low seed rate (100 kg/ha) of improved variety produced more effective tillers under famers' practice than complete package of practices. More plant height of 'Local' variety than improved variety and more spike length, spikelets/spike, grains/spike and 1,000-grain weight in improved

variety than 'Local' variety was attributed to differences in varietal characteristics. Among the fertilizer, weed management, line sowing and plant-protection measures, inclusion of recommended doses of fertilizers alone in farmers' practice brought maximum improvement in growth and yield attributes, followed by weed management, plant-protection measures and line sowing compared with farmers' practice. On the other hand, when different production factors were withdrawn from the complete package of practices the adverse effect on the growth and yield attributes was maximum due to fertilizers, followed by weed management, delayed sowing (except effective tillers), line sowing and plant-protection measures. However, on pooled basis the adverse effect on growth and all yield attributes was significant due to fertilizers and weed management only. Results are agreement with the findings of Ghosh and Mukhopadhyay (1981), Paliwal *et al.* (1995) and Singh *et al.* (1995).

Grain yield

Variation in grain yield was recorded in different years (Table 2). This was mainly due to variations in amount and distribution of rainfall in different years. Crop sown during 1996–97, 1997–98 and 1998–99 received 244.3, 328.5 and 205.6 mm total rainfall respectively. The monthly rainfall distribution pattern revealed that crop received 5.5, 0, 55.5, 11.2, 30.8, and 93.1 mm rainfall in October (after sowing), November, December, January, February, March and April, respectively, during 1996–97 while in corresponding months, there was 9.8, 51.7, 69.9, 4.7, 47.2, 82.2 and 58.0 mm rainfall during 1997–98 and 108.5, 5.0, 0, 49.2, 11.4, 0 and 0 mm rainfall during 1998–99.

Grain yield was influenced significantly due to different production factors. During all years, the highest grain yield was recorded under complete package of practices, which was 1,524 kg/ha and 101.8% more than farmers' practice. Inclusion of any production factor alone in farmers' practice resulted in higher grain yield compared to farmers' practice. However, magnitude of increase in grain yield differed greatly among production factors. Inclusion of recommended fertilizer lose and weed management alone in farmers' practice gave significantly higher yield compared with farmers' practice while inclusion of line sowing or plant-protection measures in farmers' practice failed to provide significantly more grain yield than famers' practice during all the years. Withdrawal of either production factor from complete package of practices adversely affected the grain yield when compared with complete package of practices. During all the years, reduction in grain yield was maximum (mean 42.2%) when crop was raised without fertilizers compared with complete package of practices and its inclusion in farmers' practice also contributed maximum (mean 41.9%) in increasing the grain yield over farmers' practice. Inclusion of weed management in farmers' practice and its exclusion from complete package of practices contributed almost similar and was found to be the next important production factor after fertilizer, in increasing (36.3%) and decreasing (34.9%) the mean grain yield compared to farmers' practice and complete

Table 2. Effect of production factors on grain yield and economics of rainfed wheat

Treatment	Grain yield (kg/ha)				Increase in mean grain yield (kg/ha) over FP	Decrease in mean grain yield (kg/ha) frrom CPP	Mean gross returns (Rs/ha)	Mean net returns (Rs/ha)	Additional mean net returns (Rs/ha) over FP	Loss in mean net returns (Rs/ha) from CPP
	1996–97	1997–98	1998–99	Pooled						
T_1	1,382	1,642	1,467	1,497		1,524 (50.4)	11923	1,670		–6,127
T_2	1,659	2,162	1,749	1,860	363 (24.2)	1,161 (38.4)	13,818	2,732	+1,062	–5,065
T_3	1,904	2,246	2,222	2,124	627 (41.9)	897 (29.7)	17,309	5,522	+3,852	–2,275
T_4	1,892	2,170	2,058	2,040	543 (36.3)	981 (32.5)	15,338	2,835	+1,165	–4,962
T_5	1,552	1,739	1,710	1,667	170 (11.3)	1,354 (44.8)	13,149	1,331	–339	–6,466
T_6	1,560	1,860	1,690	1,703	266 (13.8)	1,318 (43.6)	13,367	2,338	+668	–5,459
T_7	2,470	3,405	3,188	3,021	1,524 (101.8)		22,196	7,797	+6,127	
T_8	1,853	2,439	1,980	2,090	593 (39.6)	931 (30.8)	16,469	2,903	+1,233	–4,894
T_9	1,251	2,046	1,939	1,745	248 (16.6)	1,276 (42.2)	13,223	1,000	–670	–6,797
T_{10}	1,347	2,391	2,163	1,967	470 (31.4)	1,054 (34.9)	14,234	2,085	+415	–5,712
T_{11}	2,060	3,150	3,032	2,747	1,250 (83.5)	274 (9.1)	20,106	7,272	+5,602	–525
T_{12}	2,375	3,101	2,846	2,774	1,277 (85.3)	247 (8.2)	21,254	7,631	+5,961	–166
T_{13}	1,571	3,091	2,826	2,496	999 (66.7)	525 (17.4)	18,852	4,453	+2,783	–3,344
CD (P=0.05)	404	253	296	244			1,328	921		

Figures in parentheses denote % values

T_1, Farmers' practice (FP); T_2, FP + improved variety; T_3, FP + recommended fertilizers; T_4, FP+ recommended weed management; T_5, FP+ **line sowing; T_6, FP** + plant-protection measures; T_7, complete package of practices (CPP); T_8, CPP—improved variety; T_9, CPP—fertilizers; T_{10}, **CPP—weed management**; T_{11}, CPP—line sowing; T_{12}, CPP—plant-protection measures; T_{13}, CPP—timely sowing

Y_1, 1996–97; Y_2, 1997–98; Y_3, 1998–99

package of practices respectively. Excluding the improved variety from complete package of practices decreased the grain yield by 25.0–36.3% (mean 30.8% and 931 kg/ha) as compared to complete package of practices, whereas its inclusion in farmers' practice could increase grain yield by 20.0–31.7% (mean 24.2% and 363 kg/ha) over farmers' practice in different years. Crop grown under complete package of practices without line sowing and as farmers' practice with line sowing resulted in 4.9–16.6% (mean 9.1% and 274 kg/ha) decrease and 5.9–16.5% (mean 11.3% and 170 kg/ha) increase in grain yield compared with complete package of practices and farmers' practice, respectively, in different years. Plant-protection measures included in farmers' practice and its absence under complete package of practices showed 12.9–15.2% (mean 13.8% and 226 kg/ha) and 3.8–8.9% (mean 8.2% and 247 kg/ha) increase and decrease in grain yield compared to farmers' practice and complete package of practices, respectively, in different years. Delayed sowing by 15 days decreased the mean grain yield by 17.4% (525 kg/ha) over timely sowing which was 35 kg/ha/day. The reduction in grain yield due to delayed sowing was higher (36.3%) during 1996–97 compared with 9.0% only during 1997–98 and 1998–99. It was mainly attributed to poor tillering due to rain-free period during 1996–97 after sowing to January first fortnight in comparison to 121.6 mm (November 51.7 mm and December 69.9 mm) in 1997–98 and 29.5 mm (November 5.0 mm and January 24.5 mm) rainfall in 1998–99 during same period. Applying recommended fertilizer dose and weed management in farmers' practice was beneficial in terms of grain yield than when the crop raised under complete package of practices without fertilizers and weed management, respectively, except weed management during 1997–98 and 1998–99. Enhancement in grain yield due to inclusion of improved production factors in farmers' practice was attributed to favourable effects on growth and yield attributes. Similarly, reduction in grain yield due to exclusion of any production factor from complete package of practices was due to adverse effects on growth and yield attributes. Singh *et al.* (1981) and Pandey and Chauhan (1999) also reported similar results.

Economics

Inclusion of any production factor in farmers' practice gave more gross as well net returns. The highest net returns were obtained owing to inclusion of fertilizers (Rs 5,522 /ha, followed by weed management (Rs 2,835 /ha), variety (Rs 2,732 /ha) and plant-protection measures (Rs 1,338 / ha. However, inclusion of line sowing in farmers' practice resulted in the net loss of Rs 339 /ha compared to farmers' practice Rs 1,670 /ha. It was because of more cost incurred in line sowing than returns obtained from extra produce. Exclusion of different production factors from complete package of practices significantly reduced the net returns, which was in order of fertilizer (Rs 1,000 /ha > weed management (Rs 2,085 /ha) >variety (Rs 2,903 /ha) > timely sowing (Rs 4,453 /ha). However, crop raised under complete package of practices without plant-protection measures or line sowing gave net returns at par with com-

plete package of practices. Additional net returns were also higher owing to withdrawal of any production factor from complete package of practices compared with farmers' practice; however, complete package of practices without recommended fertilizer dose failed to provide net returns equal to farmers' practice.

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