Himachal Journal of Agricultural Research Vol. 32(2) : 6-14, 2006

Effect of integrated nutrient management on growth, development and biomass production in wheat (*Triticum aestivum*) – rice (*Oryza sativa*) crop sequence in north western Himalayas

Anil K. Choudhary, R.C. Thakur* and Naveen Kumar**
CSK Himachal Pradesh Krishi Vishvavidyalaya
Krishi Vigyan Kendra, Sundernagar (Mandi)–174 402.

Abstract

A field experiment was conducted in a silty clay loam soil at Palampur during *Rabi* 1999-2000 to *Kharif* 2001 in a three times replicated randomized block design. Treatments in wheat comprised of five sources of organic manures and three levels of macronutrients (50, 100 and 150 per cent of recommended NPK) alongwith one absolute control. Rice crop after wheat received recommended dose of NPK (90 kg N + 40 kg P_2O_5 + 40 kg K_2O per hectare) except absolute control to study the residual effects of treatments of preceding crop. Application of FYM @ 10 t ha^{-1} recorded significantly highest seed emergence in wheat; plant height, number of tillers m^{-2}, dry matter production m^{-2} and grain and biological yields of both wheat and rice followed by '*berseem*' green manuring + FYM or mushroom spent compost + FYM, mushroom spent compost and '*berseem*' green manuring, respectively during both the years. Growth as well as biomass production in terms of grain and biological yields of both wheat and rice crops was also increased consistently and significantly with increase in fertilizer levels from 50 to 150 per cent of recommended NPK in wheat - rice crop sequence. Integrated use of FYM @ 10 t ha^{-1} alongwith 150 per cent of recommended NPK resulted in significantly highest growth, biomass production and productivity of both wheat and rice over other treatment combinations of organics and chemical fertilizers during experimentation.

Key words: Rice, wheat, organics, NPK, growth and yield parameters, productivity.

Introduction

Rice–wheat cropping system occupies about 22 million hectares area in Northern India, Pakistan, Bangladesh and China. In India, it covers about 10 million hectares area and contributes to 22 per cent of total foodgrain production (Sharma, 2005). In Himachal Pradesh, these crops are grown on about 50 per cent of the total cropped area and together they account for 43-44 per cent of total food grain production of the state (Thakur *et al.*, 1994). Rice–wheat cropping system is a major food yielder cropping system in the hill region of north-western Himalayas in general, and Himachal Pradesh in particular; but this system is heavy feeder of nutrients and renders the soil unproductive if not supplemented with adequate nutrients. Simultaneously, the poor economic conditions of hill farmers and high price of chemical fertilizers discourage them to meet out the nutritional requirements of these crops fully through chemical fertilizers. Thus, integrated plant nutrient management system (IPNS) using locally available organics with chemical fertilizers appears to be the best alternative in bridging the gap between nutrient requirement and the supply of intensive rice–wheat cropping system in the region.

In Himachal Pradesh, most of FYM obtained from domestic animals finds its way in fields, which is generally added in the wheat crop following rice to improve the soil physical properties disturbed due to wet tillage in rice. Besides FYM, mushroom spent compost is another source of plant nutrition available in mid Himalayan region. Another alternate is growing of *berseem* legume as green manure crop in standing rice crop without loosing main crop of wheat, which is a common practice in rice growing belt of lower and mid region of north-western Himalayas. Thus, keeping in view the above facts; integrated nutrient management through locally available organics and chemical fertilizers can hold great promises in wheat–rice crop sequence without affecting the age old

**Former Director of Research, CSK HPKV, ** Department of Agronomy, CSK HPKV, Palampur.*

practice of adding organics in wheat crop by hill farmers. Since, little information is available on effect of addition of organics in wheat on growth, development and productivity of succeeding rice crop as well as system as a whole in north-western Himalayas. Therefore, present investigation was undertaken to study the effect of integrated nutrient management on growth, development and biomass production in wheat–rice crop sequence in north-western Himalayas.

Material and Methods

A field experiment was conducted at Experimental Farm of Department of Agronomy, CSK HPKV, Palampur, Himachal Pradesh (32° 6' N, 76° 3' E, 1290.8 m above mean sea level) in a silty-clay loam soil from *Rabi* 1999-2000 to *Kharif* 2001 under randomized block design replicated thrice with five levels of organic manures (OM_1 – FYM @ 10 t/ha on oven dry weight basis; OM_2 – mushroom spent compost @ 10 t/ha on oven dry weight basis; OM_3 – "*berseem*' *in situ* green manure; OM_4 – mushroom spent compost @ 5 t/ha on oven dry weight basis + FYM to supply remaining N equivalent to OM_1 on oven dry weight basis; and OM_5 – '*berseem*' *in situ* green manure + FYM to supply remaining N equivalent to OM_1 on oven dry weight basis) and three fertilizer levels i.e. 50 (F_{50}), 100 (F_{100}) and 150 (F_{150}) per cent of recommended NPK in wheat along with one absolute control. All the organics were incorporated in the soil before wheat sowing as per the treatments in this fixed plot experiment. Rice was grown with 100 per cent of recommended NPK fertilizers (90 kg N + 40 kg P_2O_5 + 40 kg K_2O per hectare) except control to study the direct and residual effects of integrated nutrient management on growth, development and biomass production in wheat–rice crop sequence in north-western Himalayas.

Wheat 'HPW-89' was sown in rows 20 cm apart using seed rate of 100 kg ha^{-1} on 19th and 11th November and harvested on 20th and 13th May during *Rabi* 1999-2000 and 2000-2001, respectively; whereas rice 'RP-2421' was transplanted at spacing of 20×15 cm on 9th July and harvested on 14th October during both the years, respectively. The gross plot size both in wheat and rice was kept 16.20 m^2 whereas respective net plot size was 11.20 m^2 and 10.92 m^2. Soil pH, organic carbon, total nitrogen and available N, P and K in soil samples were worked out by standard methods and the soil was categorized as medium in organic carbon (0.80 %), total N (0.113 %), available nitrogen (284.3 kg/ha) and available phosphorus (18.9 Kg/ha), and high in available potassium (249.5 Kg/ha) and acidic in reaction (5.6). Before application and incorporation in soil, different organic sources of plant nutrients were analyzed for their chemical composition with respect to nitrogen, phosphorus and potassium contents on dry weight basis during both the years of experimentation (Table 1).

The average nutrient addition through *berseem* green manure during both years was thoroughly calculated after computing dry matter yield and chemical analysis of produce. After addition of mushroom compost and *berseem* green manure in OM_4 and OM_5 treatments, respectively; the additional quantity of FYM was added to make the supply of nitrogen in these treatments equivalent to OM_1 (FYM @ 10 t/ha). The amount of N, P and K added in soil by organic manures as per the treatments at wheat

Table 1. Nutrient composition of organic manures on oven dry weight basis

Organic manures	Chemical composition (%)					
	Year 1999			Year 2000		
	N	P	K	N	P	K
FYM	0.80	0.24	1.03	0.83	0.28	0.95
Mushroom spent compost	0.33	0.14	0.32	0.33	0.14	0.32
Berseem 'GM'	2.10	0.39	1.68	2.18	0.35	1.68

sowing during both the years of experimentation, is given in Table 2.

Emergence count per m^2 in wheat was worked out from three randomly selected observational units of one meter row length each from each net plot till constant number of germinated seeds was not obtained. Average number of wheat seeds used per m^2 for sowing was 220 in each plot during both the years; on the basis of which emergence percentage in wheat was worked out. The observations on growth characters *viz.*, plant height, dry matter accumulation and number of tillers per m^2 in wheat and rice were recorded at periodical interval of 30 days till harvest. A crop sample of 50 cm row length, 25 cm row length from each sample row was taken for dry matter accumulation studies in wheat. While in rice a crop sample of 60 cm row length, 30 cm row length (two plants) from each sample row was taken for this purpose. The samples were oven dried at 70°C temperature till constant weight and dry weight thus recorded was converted into g per m^2 of ground area. For recording progressive number of tillers in wheat and rice, three observational units of one meter row length each were selected randomly from net plot and counting was done accordingly and then mean value was converted into number of tillers per m^2. For plant height measurement, 10 randomly selected plants were tagged in net plot area after emergence of wheat/ transplanting of rice and then averaged to express plant height in cm. The grain and biological yield was expressed as q ha^{-1}. Statistical analysis was done by the standard procedures suggested by Gomez and Gomez (1984).

Results and Discussion

Emergence count in wheat

During *Rabi* 1999-2000, neither organic manures nor chemical fertilizers had any significant influence on the seed emergence count of wheat crop (Table 3). During *Rabi* 2000-2001, application of FYM alone (OM_1) or in combination with mushroom spent compost (OM_4) or *berseem* 'GM' (OM_5) remaining at par with each other significantly improved the emergence count of wheat crop, while significantly minimum emergence count of wheat was observed in *berseem* green manured plots (OM_3). Emergence count of wheat also improved significantly with increasing chemical fertilizer levels from 50 to 150 per cent of recommended NPK during *Rabi* 2000-2001. Organic matter addition through FYM application in soil helps in increasing the soil temperature by increasing the heat absorbance from the sun which thereby enhances germination, emergence and growth of the crops in low temperature soils (Patil and Bhardwaj, 1976). Thus, organic matter addition through various organic manures as well as dry matter addition through crop stubbles because of increased productivity as a result of increased chemical fertilization; might have been the reasons for improving the emergence count of wheat. On an average, emergence percentage of wheat thus recorded was in accordance with emergence count and followed the similar trend as that of emergence count in wheat during both the years. All the plots imposed with organic manures and chemical fertilizer treatments maintained their significant superiority over absolute

Table 2. Nutrient additions (kg/ha) in soil through organic manure treatments during *Rabi* 1999-2000 and 2000-2001

Treatment	*Rabi* 1999-2000			*Rabi* 2000-2001		
	N	P	K	N	P	K
OM_1	80	24	103	83	28	95
OM_2	33	14	32	33	14	32
OM_3	13.7	2.3	11	16.7	2.7	12.9
OM_4	80	26.1	97.8	83	29.4	92.1
OM_5	80	22.2	96.3	83	25.1	88.8

Table 3. Effect of organic manures and chemical fertilizers on emergence count per m^2 and emergence percentage in wheat during field experimentation

Treatments	*Rabi* 1999-2000		*Rabi* 2000-2001	
	Emergence count	Emergence (%)	Emergence count	Emergence (%)
Organic manures				
OM_1	198.1	90.1	199.3	90.6
OM_2	197.9	90.0	198.6	90.3
OM_3	197.4	89.7	198.0	90.0
OM_4	198.1	90.1	199.4	90.6
OM_5	197.6	89.8	199.1	90.5
CD (P=0.05))	NS	-	0.92	-
Chemical fertilizers				
F_{50}	197.2	89.6	197.4	89.7
F_{100}	198.3	90.1	199.2	90.5
F_{150}	198.0	90.0	200.0	90.9
CD (P=0.05))	NS	-	0.71	-
Control vs Others				
Control	195.5	88.9	195.1	88.7
Others mean	197.8	89.9	198.9	90.4
CD (P=0.05))	2.02	-	1.16	-

control with respect to emergence count and emergence percentage of wheat during both the seasons of experimentation.

Growth and development in wheat and rice

Various growth parameters under study included plant height, number of tillers m^{-2} and dry matter accumulation (g m^{-2}). The mean data of growth parameters of two years of both wheat and rice is presented graphically in figures 1 to 6. In general, growth behaviour of wheat and rice under study revealed that plant height of wheat upto 150 days after sowing (DAS) and of rice upto 90 days after transplanting (DAT) increased progressively irrespective of the treatment effects and thereafter remained constant till maturity (Fig. 1 & 4). Dry matter accumulation in wheat increased slowly upto 60 DAS, thereafter the rate of dry matter accumulation was quite fast upto 150 DAS, but after that the rate got lowered down upto maturity irrespective of the application of organic manures and chemical fertilizers (Fig. 2). The rate of dry matter accumulation in rice crop was quite fast upto 90 DAT, but afterwards the rate got lowered down upto maturity irrespective of the treatments in the present study (Fig. 5). Tiller count per m^2 in wheat and rice (Fig. 3 & 6) indicated a linear increase upto 90 DAS in wheat and upto 60 DAT in rice irrespective of the treatments and thereafter the tiller count got stabilized in both the crops irrespective of the treatments during field experimentation.

Growth parameters i.e. plant height, number of tillers m^{-2} and dry matter accumulation m^{-2} both in

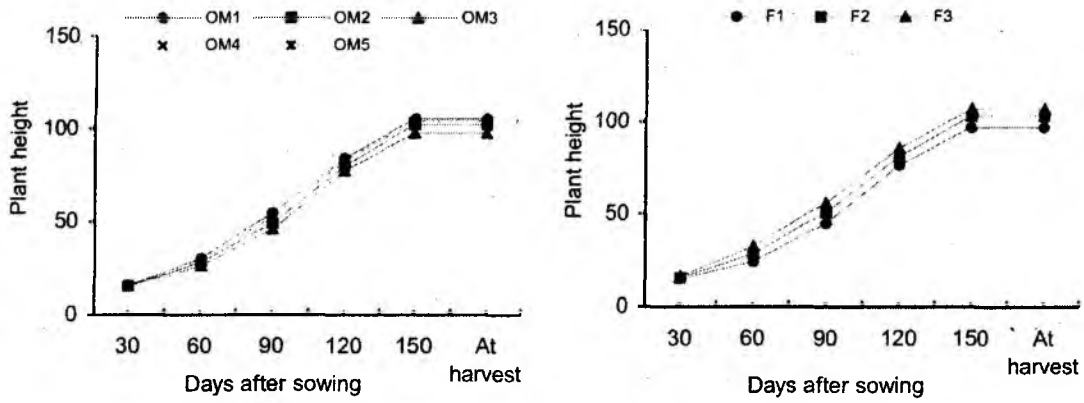


Fig. 1 Effect of organic manures and chemical fertilizers on plant height (cm) of wheat at 30 days interval

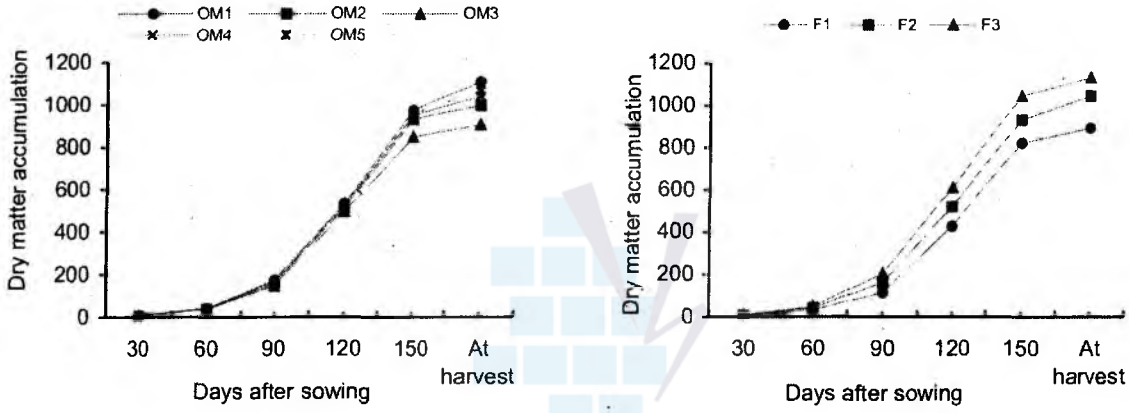


Fig. 2 Effect of organic manures and chemical fertilizers on dry matter accumulation ($g\ m^{-2}$) in wheat at 30 days interval

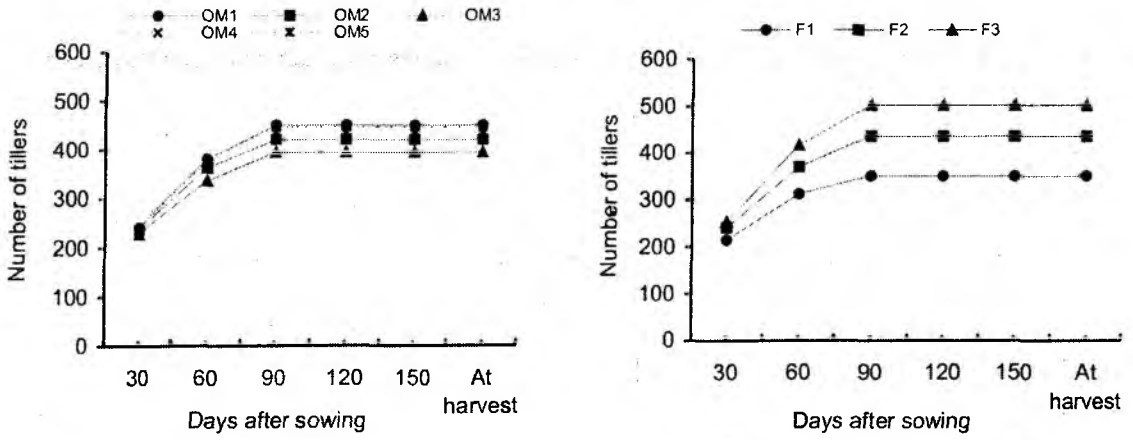


Fig. 3 Effect of organic manures and chemical fertilizers on number of tillers per m^2 in wheat at 30 days interval

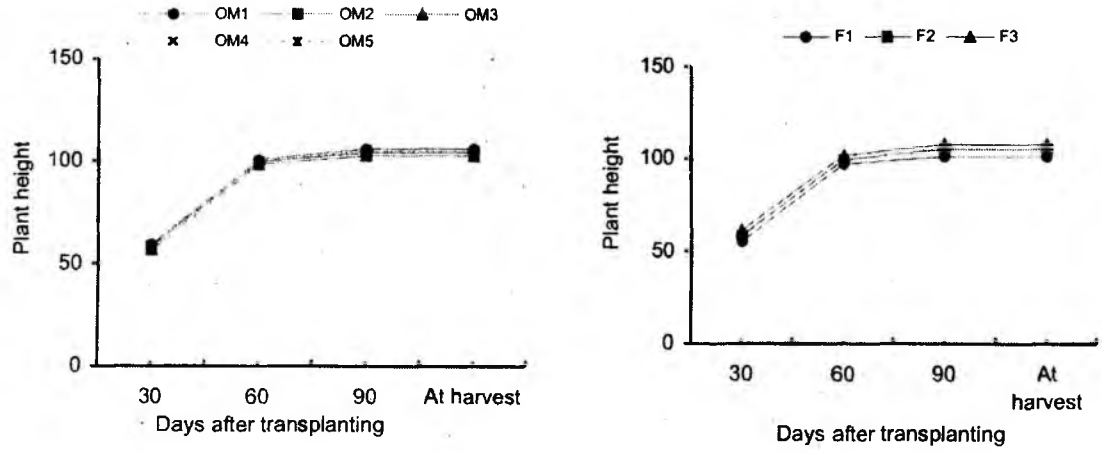


Fig. 4 Effect of organic manures and chemical fertilizers on plant height (cm) of rice at 30 days interval

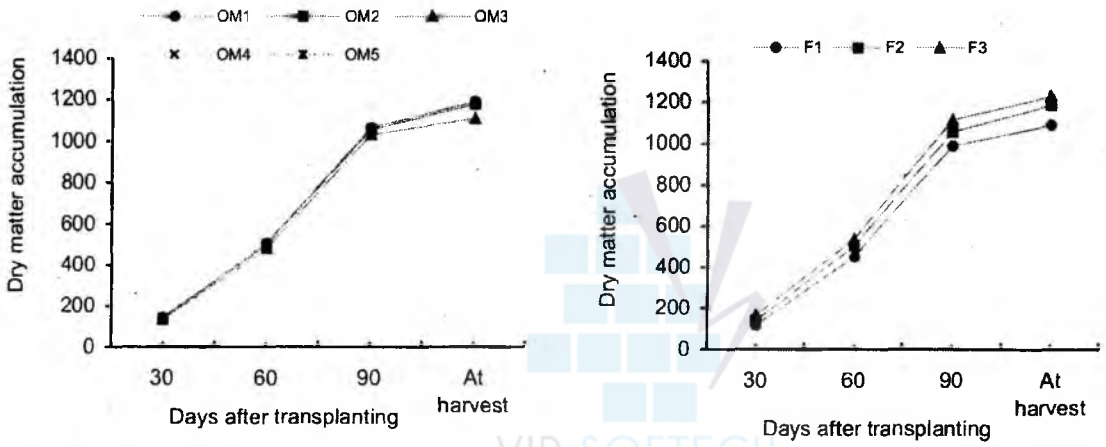


Fig. 5 Effect of organic manures and chemical fertilizers on dry matter accumulation (g m^{-2}) in rice at 30 days interval

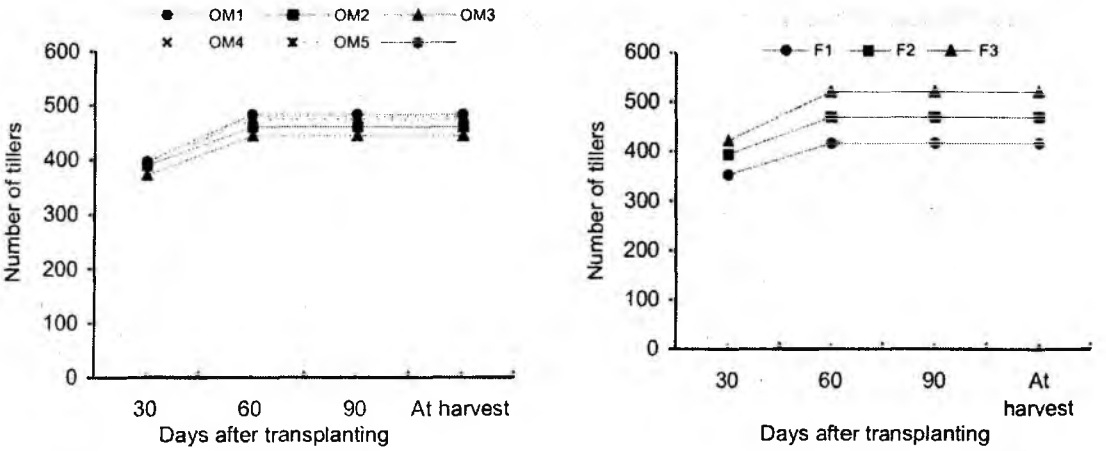


Fig. 6 Effect of organic manures and chemical fertilizers on number of tillers per m^2 in rice at 30 days interval

wheat and rice, were better in FYM applied plots (OM_1) and were followed by *berseem* green manuring + FYM (OM_5) or mushroom spent compost + FYM (OM_4), mushroom spent compost (OM_2) and *berseem* green manured plots (OM_3), respectively at all the dates of observations during experimentation (Fig. 1 to 6). The growth was considerably poor in absolute control as compared to other treatments during the study. In the present study, various organic manures added good amount of N, P and K in soil (Table 2); besides, these organics might have also provided other essential macro and micronutrients for plant growth. Organic matter is an important soil component influencing the physical, chemical and microbiological properties of the soils (Allison, 1973; Guar, 1979; Thakur *et al.*, 1995) as well as soil fertility status to a great extent (Thakur *et al.*, 1999). Thus, improvement in physico-chemical and microbiological properties of soil might have favoured the growth and development of crop plants in the present study. Comparatively lower magnitude of crop growth was observed in plots green manured with *berseem* at all the dates of observations. Shorter period of *berseem* cultivation before wheat sowing resulted in low biomass production of this legume which accounted for low nutrient additions (Table 2) which might have resulted in comparatively poor crop performance in terms of growth parameters in this treatment. On the other hand, FYM application accounted for comparatively higher addition of plant nutrients (Table 2) followed by mushroom spent compost or *berseem* green manuring both in combination with FYM, and mushroom spent compost alone, respectively; because of which the FYM application proved its superiority on crop growth parameters over other organics at all the dates of observations in the present study (Fig. 1 to 6). These results are in confirmity with those of Sharma (1983).

Significant increase in plant height, number of tillers and dry matter accumulation in wheat and rice was also observed with increase in chemical fertilizer levels from 50 to 150 per cent of recommended NPK in wheat crop, at all the dates of observations during study (Fig. 1 to 6). Plant height increased significantly and consistently with increasing levels of fertilizers with significantly taller plants in plots receiving 150 per cent of recommended NPK (Fig. 1 & 4). During the entire period of study, absolute control resulted in shortest plants of both crops over other treatments. The initiation and development of tillers is very much dependent on the concentration of N, P and K in the mother stem at tillering stage of crop (Honya, 1961). Hence, increased fertilizer levels from 50 to 150 per cent of recommended NPK are expected to increase the respective nutrient content in the plants at tillering stage, resulting in significant increase in number of tillers m^{-2} of both the crops. The accumulation of carbon and crop biomass depends upon the formation of organs for nutrient absorption (root) and photosynthesis (leaf canopy). Consequently, with the increase in plant height (Fig. 1 & 4) and number of tillers in wheat and rice (Fig. 3 & 6) with increased fertilizer rates; dry matter accumulation also increased at all the dates of observation. There was progressive increase in dry matter accumulation with increase in crop age upto maturity (Fig. 2 & 5). These results are in close confirmity to those obtained by Sharma (1983) and Choudhary *et al.* (2004).

Productivity and biomass production in wheat and rice

Application of various organic manures in wheat significantly influenced the grain and biological yields in wheat and rice crops with significantly highest magnitude in FYM added plots @ 10 t/ha (OM_1) followed by green manuring of *berseem* + FYM (OM_5) or mushroom spent compost + FYM (OM_4), mushroom spent compost (OM_2) and '*berseem*' green manure (OM_3), respectively during both the years (Table 4) and followed the similar trend as that of growth parameters of crop plants indicating that growth parameters have great bearing on yield expression of crop plants. These results are in close conformity with those of Sharma (1983) and Sharma (1992).

The growth parameters of wheat and rice crops at varying fertility levels also had close association with biomass production of these crops. Thus, increase in chemical fertilizer levels from 50 to 150 per cent of recommended NPK to wheat resulted in consistent and significant increase in the wheat grain and biological yields due to direct effect of NPK. Similar trend was also observed with respect to grain and biological yields of rice crop on account of the residual effects of fertilizer levels imposed in previous wheat crop (Table 4). Absolute control devoid of any nutrient application exhibited significantly lower biomass production in terms of grain and biological yield in wheat and rice over other treatments during both the years. Sharma

Table 4. Effect of organic manures and chemical fertilizers on grain and biological yield (q ha^{-1}) in wheat-rice crop sequence

Treatments	Wheat				Rice			
	Rabi 1999-2000		*Rabi* 2000-2001		*Kharif* 2000		*Kharif* 2001	
	Grain yield	Biological yield	Grain yield	Biological yield	Grain yield	Biological yield	Grain yield	Biological yield
Organic manures								
OM_1	44.75	104.37	45.72	109.15	44.66	111.70	47.46	118.42
OM_2	38.96	91.17	41.16	98.23	43.16	107.24	46.50	116.11
OM_3	35.35	82.50	36.74	87.56	41.20	102.03	45.21	112.17
OM_4	40.86	95.38	41.76	99.72	44.27	110.49	46.78	116.85
OM_5	42.45	98.95	42.86	102.38	43.21	108.09	46.99	117.37
CD (P=0.05))	0.82	1.96	0.83	1.99	0.47	1.20	0.23	0.59
Chemical fertilizers								
F_{50}	35.03	82.15	35.34	84.34	41.39	101.50	43.90	108.29
F_{100}	41.48	96.60	43.33	103.30	43.16	108.02	46.84	117.29
F_{150}	44.91	104.67	46.27	110.59	45.35	114.22	49.03	122.96
CD (P=0.05))	0.63	1.52	0.64	1.54	0.36	0.93	0.18	0.45
Control vs Others								
Control	18.87	44.45	13.21	32.57	18.94	45.47	11.96	29.31
Others mean	40.47	94.47	41.65	99.41	43.30	107.91	46.59	116.18
CD (P=0.05))	1.03	2.49	1.05	2.52	0.59	1.51	0.30	0.74

(1992) and Choudhary *et al.* (2004) have also observed similar results with variable fertilizer levels. Interaction effects of organic manures and chemical fertilizers on grain and biological yields of wheat and rice were significant during both the years. FYM in combination with 150% of recommended NPK applied to wheat crop registered maximum productivity in terms of grain and biological yields in wheat-rice sequence which was followed by mushroom compost + FYM + 150% of recommended NPK, *berseem* 'GM' + FYM + 150% of recommended NPK, and FYM + 100% of recommended NPK, respectively. *Berseem* 'GM' + 50% of recommended NPK registered lowest productivity of the sequence. However, in general, FYM application @ 10 t ha^{-1} + 150% of recommended NPK in wheat crop and 100% of recommended NPK in rice crop accounted for higher productivity in wheat-rice sequence in the present study.

From the above study, it can be concluded that integrated nutrient management through organics and chemical fertilizers greatly influenced the growth parameters of wheat and rice besides physiological behaviour of these crops. Further, it is revealed that FYM application @ 10 t/ha alone or in combination with other locally available organics *viz.* mushroom spent compost and *berseem* green manuring as well as increasing chemical fertilizer levels from 50 to 150 percent of recommended NPK in wheat resulted in higher magnitude of plant growth parameters as well as significantly higher biomass production in terms of grain and biological yield in wheat-rice crop sequence due to direct as well as residual effects of these treatments. The study concluded that FYM application @ 10 t ha^{-1} in combination with 150% of recommended NPK in wheat crop and 100% of recommended NPK in rice crop accounted for highest growth and productivity in wheat-rice sequence in the present study in north-western Himalayas.

References

Allison, F.E. 1973. Soil organic matter and its role in crop production. *In*: *Development in Soil Science* 3, Elsevier, Amsterdam. 637 p.

Choudhary, A.K., Badiyala, D., Negi, P.S. and Singh, K.P. 2004. Physiological response of *Brassica species* to varying fertilizer levels under rainfed mid hill conditions of north-western Himalayas. *Journal of Nature Conservation* 16 (1): 67-76.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research*. A Wiley-Interscience Publication, John Wiley and Sons Inc., New York, USA.

Guar, A.C. 1979. Organic recycling prospects in Indian agriculture. *Fertilizer News* 29 (2): 49-61.

Honya, K. 1961. Studies on improvement of rice plant cultivation in volcanic ash paddy field in Tohaku District. *In*: *Crop Physiology* Ed. by T.T. Evans, Cambridge University Press. 74 p.

Patil, B.R. and Bhardwaj, R.B.L. 1976. Agro-techniques for late sown wheat. *Indian Journal of Agricultural Sciences* 46 (2): 57-60.

Sharma, G.D. 1992. Fertility management and crop geometry for yield maximization in rice-wheat cropping system. *Ph.D. thesis*, submitted to HPKV, Palampur .

Sharma, S.N. 2005. Integrated nutrient management in rice-wheat cropping system. *Fertilizer News* 50 (2): 53-71.

Sharma, H.L. 1983. Studies on the utilization of crop residues, farmyard manure and nitrogen fertilization in rice-wheat cropping system under sub temperate climate. *Ph.D. thesis* submitted to HPKV, Palampur .

Thakur, R.B., Chaudhary, S.K. and Jha, G. 1999. Effect of combined use of green manure crop and nitrogen on productivity of rice-wheat system under lowland rice. *Indian Journal of Agronomy* 44 (4): 664-68.

Thakur, R.C., Bindra, A.D., Sood, R.D. and Bhargava, M. 1995. Effect of fertilizer application and green manuring on physico-chemical properties of soil and grain yield of rice-wheat crop sequence. *Indian Journal of Agronomy* 40 (1): 4-13.

Thakur, R.C., Sood, R.D., Bhargava, M. and Chaudhary, J.B. 1994. Present status and future strategies for research in rice-wheat cropping systems in Himachal Pradesh. *In*: Proceedings of symposium on sustainability of rice-wheat cropping in India, CCS HAU, Hissar, India. pp. 9-17.