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Grain production of wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) at different altitudes in Garhwal Himalaya, India

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To estimate the grain production of wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.), at three different altitudinal regions (i.e., tropical, sub-tropical and temperate) were selected. At each altitude two villages one of irrigated and another rain fed agriculture systems were taken to compare grain production between the agriculture systems and further agriculture systems of each altitude was compared along altitudinal basis. The irrigated villages were Ganga Bhogpur, Bhainswara and Dhaulana in the tropical, sub-tropical and temperate regions and rain fed villages were Kunow, Ghargoan and Chunnikhal in respective regions. Among the irrigated villages, maximum production of wheat was in the village Bhainswara (sub-tropical region) followed by the village Ganga Bhogpur (tropical region) and Dhaulana (temperate region). The highest grain production of wheat in the village Bhainswara could be due to highest input of labour energy and optimum availability of nutrients in the soil. In rain fed villages the production of wheat was comparatively lower then irrigated. Similarly, for rice higher inputs (human and bullock labour, chemical fertilizer) favoured highest grain production in Ganga Bhogpur. Among the villages Ganga Bohpur produced 1.79 kg/capita/day grain production of wheat followed by 1.0 kg/capita/day of rice which was observed sufficient food production for subsistence to the villagers (as villagers opinion said) whereas, other villages have comparatively lower grain production. The average output: input ratio across all the study regions were 1.73 (tropical), 0.99 (sub-tropical), and 0.91 (temperate), which decreased with increasing altitudes. The agriculture productions in lower altitudes are comparatively good for the villager subsistence requirement than the higher hilly agriculture production. Although throughout the year nutrient level (phosphorus and potassium) were lowest in the temperate region. The grain production of crop reduced with increasing altitude because of low photoperiod in the high altitude which influences the grain production of both the crop with increasing altitude therefore increasing altitude people are not getting their proper food requirement and migrating towards plain to fulfill their subsistence need. Thus these traditional agricultural production can be saved through encourage people by producing organic farming for high economic value for livelihood security.

Key words: yield production, energy budget, nutrient status, Garhwal Himalaya

INTRODUCTION

In the Garhwal Himalaya, agriculture is closely linked with the forestry sectors. Farming systems developed in the hills are managed by village farmers. The terraces and terrain agricultural field in hill is difficult to use with modern practices and therefore only traditional methods are dominant. The agricultural filed based on irrigation in the hills are of two types, one is irrigated where agricultural fields depend on natural streams (brook) for irrigation and second is rain fed agriculture where agriculture depends on seasonal monsoon.

Wheat (*Triticum aestivum* L.) and rice (*Oryza sativa* L.) are the main rotational crops of this region with association of other important traditional crops. Wheat is a chief source of food for a great deal of population of the world. The high demand and adaptability, wheat is grown on a large area of the world all round the year. Wheat is regarded as the most important cereal both in respect of area and dietary need of people. A healthy wheat crop is a symbol of prosperity and also an important source of strength for the nation (Shafi et al. 2004). India produces about 70 million tones per year or about 12 percent of world production. India being the second largest country in population, it is also the second largest in wheat producer and consumer after China. It is cultivated from a sea level up to even 3000 meter. More than 95 percent of the wheat area in India is situated in the northern part. It has wide range of climatic zones form tropical to temperate. It can tolerate sever cold and snow and optimum temperature for germination range from 20-25^{o}C and for plant maturity range from 14-15^{o}C. A well distributed winter rainfall of 15-20 cm is required for rain fed cropping pattern and plants required humidity of 50-60%. Sandy loams and black soil conditions and pH of neutral range of 6-8 are good for plants.

After wheat production, the second large produced crop of India is rice which also considered the most important food crop of the world. It has been the primary staple food for millions of people, for centuries. Rice is also the main livelihood of rural population in many Asian, African and Latin American countries (Labrada 1998). According to the food and Agriculture Organization, the global rice requirement in 2050 will be 800 million tones. The present production is little less than 600 million tones and an additional 200 million tones will have to be produced by increasing productivity per

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hectare to meet the future requirement (Swaminathan 2006). Of the total of 43 m ha of area under rice, about 46 percent is irrigated and 54 percent is rain fed.

Agricultural is the main stay of the people of Uttarakhand. Of the total population, more than 75% people are engaged either with the main occupation of agriculture or its allied practices (Sati 2005). Among the principal crops wheat, rice, millets, barley, pulses and oil-seeds are grown in the entire state. Source data of Directorate of Economics and Statistics, Dheradun, Uttarakhand, wheat occupies highest percent in the total sown area followed by rice and other crops, wheat and rice are grown as major rotational crops in winter (rabi) and summer (kharif) seasons respectively (Sati 2005).

Considering the importance of wheat and rice production and major consumption in different parts of country as general and in Uttarakhand region of Garhwal Himalaya as particular, the present study was undertaken in Garhwal region of Himalaya to understand (1) The grain production of wheat and rice crops in irrigated and rainfed fields at different altitude and (2) Soil nutrients status of irrigated and rainfed fields at different altitudes.

MATERIALS AND METHODS

Six agricultural fields, two each in tropical, sub-tropical and temperate regions were selected for the study (Table 1). Between the agricultural fields at each altitude one was irrigated and another rain fed in nature, were selected to compared grain production, and further grain production was compared along altitudinal gradients. Climatically spring, summer, rainy and winter are well marked seasons in this region. The summer in the tropical region are very hot and mean annual temperature was over 18-24^o C. In sub-tropical region the mean annual temperature ranges between 17-23^o C which is mild hot in summer and in temperate region the mean annual temperature was quite lower between 7-15^o C which reach some time below freezing point in winter. The photoperiod of the hills is slightly lower due to valley of hilly terrain. Although in lower region particularly in tropical, plants get maximum time for photosynthesis period and influence yield of crops. In each region the maximum average rainfall received during mid June to September (monsoon season). Snowfall usually occurs plenty in temperate region in winter season. Kharif (April-October) and Rabi (November-March) were the dominant cropping pattern in a year. *Oryza sativa, Eleusine coracana, Vigna mungo, Glycine soja, Echinochloa frumentacea* were associated crops of kharif in summer season however, *Triticum aestivum, Hordeum vulgare, Brassica campestris, Pisum stivum* were of rabi crops in winter season. The natural streams and brooks were the important source of irrigation in agricultural field however; other agricultural fields where stream flows are below agricultural land fully rain fed in nature.

The agriculture depended villages were selected and a complete survey was made at a household level for each village. All the relevant informations were collected form the villagers by repeated field visits over a period of complete year. The energy budget for each crop was calculated through personal observations in the filed when farmers were engaged in agricultural activities. Grain production of both crops was taken at the time of harvest at maturity. Grain production of crops was measured using ten quadrats of 1 m x 1 m^2 size and all the plants in each quadrate of crops were harvested. The energy budget was calculated separately for each crop as described by Maikhuri and Ramakrishnan (1990). The input values were calculated in terms of work human (man-days) and bullock (bullock-days) power and quantities of seed and fertilizer used. The output was calculated as grain production of crop and other components as by-products separately. The output and input values were converted into energy by multiplying the quantities (days) using the caloric equivalents reported by Mitchell (1979). The caloric equivalent was based on data from Pimentel et al. (1973) and Gopalan et al. (1978). The energy efficiency of each crop was calculated as a ratio between outputs and inputs.

The soil samples for analysis were collected from 0-15 cm depth for both the crops separately. The soil pH (1:2.5 ratio of soil: disttle water) was calculated using dynamic digital pH meter. The percent soil organic carbon (SOC) was determined by Walkley and Black's rapid titration method (Walkley and Black 1934). Available phosphorus (P) was determined by phosphomolybdnum blue colorimetric methods (Jackson 1958). The exchangeable potassium (K) was determined by Flame Photometer after leaching the soil with I.P ammonium acetate solution (Jackson 1958).

Table 1. Preliminary survey of the study villages

Parameter	Tropical		Sub-tropical		Temperate	
Altitude (masl)	300-400		900-1300		1900-2400	
Latitude & longitude	30^0 6' N & 70^o 38'E		30^0 29' N & 78^0 24' E		30^0 23' N & 78^0 20' E	
Villages	Ganga Bhogpur	Kunow	Bhainswara	Ghargoan	Dhaulana	Chunnikhal
Mode of irrigation	(irrigated)	rain fed	(irrigated)	rain fed	(irrigated)	rain fed
Mode of irrigation	irrigated	rainfed	irrigated	rainfed	irrigated	rainfed
Cultivated land ha^{-1}	225	15	24.42	18.32	50.16	14.32
Human density ha^{-1}	0.25	0.06	0.10	0.12	0.16	0.09

RESULTS AND DISCUSSION

Agriculture production is the main occupation of vast majority of the people of this region except few landless people. The highest cultivable agriculture area was in the village Ganga Bhogpur of tropical region and the lowest in the agriculture of village Chunnikhal of temperate region. Energy values for different items used in the villages are presented in Table 2. Among the irrigated fields maximum grain production of *Triticum aestivum* was in the village Bhainswara followed by Ganga Bhogpur and Dhaulana (Fig.1). However, in rainfed villages the grain production was maximum in the village Kunow followed by Chunnikhal and Ghargoan (Fig.1). Among the irrigated villages the highest grain production of *Triticum aestivum* in the village Bhainswara could be due to optimum inputs and amount of availability soil nutrients (Fig. 3a and 3b) in the agricultural filed. The lowest production of *Triticum aestivum* in Dhaulana village agriculture might be lower inputs and lower amount of phosphorus and potassium nutrients in the soil (Fig. 3b). Among the rain fed villages, maximum grain production of *Triticum aestivum* was in village Kunow because of higher amount of organic carbon, phosphorus, potassium. Similarly the lowest production was in the village Ghargoan which mighty be due to lower availability of soil organic carbon.

The production of *Triticum aestivum* in rain fed villages was comparatively lower than irrigated agriculture filed because of low moisture content in soil and agriculture field were invaded by weeds which reduced the total grain production. Among the various factors affect wheat production, the role of irrigation and fertilizers inputs assume greater significance. Water and fertilizer resources need judicious use for obtaining maximum output (Jadhav et al. 1981). Misra et al. (1969) and Fischer et al. (1977) reported an increase in yield of wheat with an increase in the wetness of regimes and recommended adequate irrigation throughout the growing season without subjecting to water stress. Chowdhary and Pandey (1975) and Shekhawat et al. (1975) have reported that the proper integration of soil moisture and fertilization can boost the yields to the levels higher than their singular effects. May suggest other thing

The higher production of *Oryza sativa* in village Ganga Bhogpur might be due to higher input values of human and bullock labours, moreover the villagers also used chemical fertilizer in the crop which provides favourable conditions for its better production. The lower production of *Oryza sativa* was in the agriculture of village Dhaulana where labour input was lower. In rain fed, the lower production of *Oryza sativa* was in Kunow where the labour and compost inputs also were lower. It was interesting to note that as observed from the village Chunnikhal, the production of *Oryza sativa* was not recorded. Villagers suggested that in adjacent villages *Oryza sativa* is normally grown, but in Chunnikhal complete plant of *Oryza sativa* grows and no grain production occurred, therefore people neglect its production. It is expected that the grain production of *Oryza sativa* in Chunnikhal village affected due lower amount of phosphorus in the soil and may also some physiological problems in root activity of plant. Bhardwaj and Wright (1967) observed that in many soils deficient in available phosphorus would be impossible to get the potential yield without adding the amount of phosphorus.

The agricultural field of different villages were

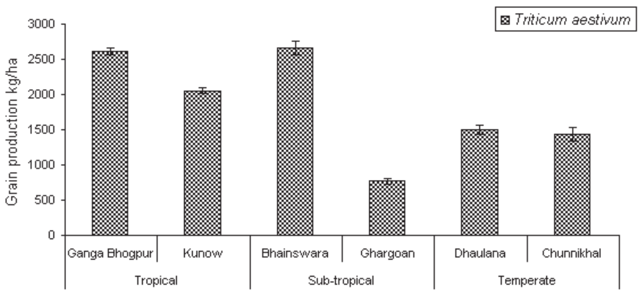

Fig. 1: Grain production of wheat at six different villages

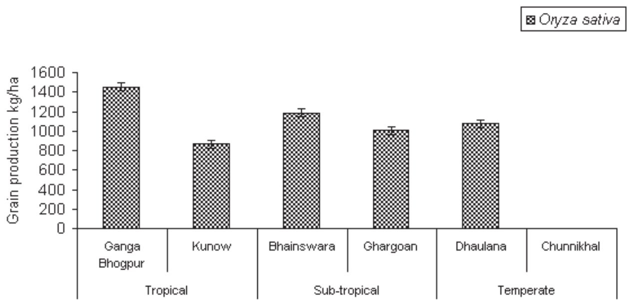

Fig. 2: Grain production of rice at six different villages

Tables 2. Energy value for different items used in the villages (values expressed as dry wt. MJ per kg)

C Category	MJ per kg	MJ per day
[a]Grain	16.2	-
[a]Straw	14.0	-
[c]Rice barn	16.4	-
[c]Farmyard manure	7.3	-
[c]Goat dung	2.0	-
[c]Cow dung	2.1	-
[a]One man day^{-1}	-	16.6
[a]One bullock day^{-1}	-	72.4

[a]Mitchell (1979), [b]Gopalan et al. (1978), [c]Maikhuri and Ramakrishnan (1991)

analyzed for per capita per day grain production and among those villages only Ganga Bhogpur produced more that 1.79 kg/capita/day of *Triticum aestivum* and 1.0 kg per capita per day of *Oryza sativa*, which can be considered only sufficient food production for subsistence for the villagers as the villagers suggested that they produced enough grain production throughout the year. Whereas, other villages have shown lower production of crop. The average output: input ratio across all the study regions were 1.73 for tropical, 0.99 for sub-tropical, and 0.91 for temperate region (Table.3). These values were quite higher than the values reported (0.43) by Pandey and Singh (1984) for Central Himalaya. It is found that output: input ratio decreased with increasing altitudes.

Grain production of both the crop was higher in irrigated fields compared to rain fed. Irrigation usually helps

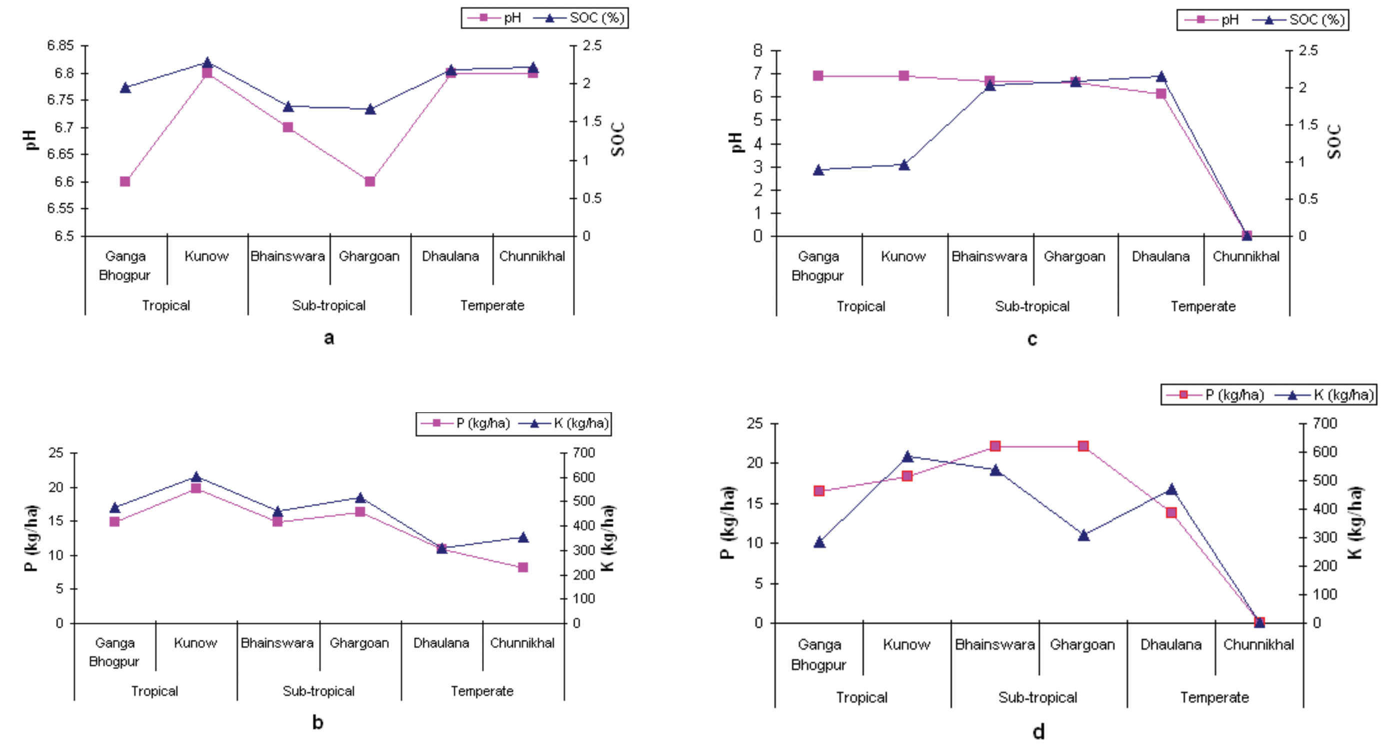

Fig. 3 a, b (wheat) and c, d (rice) of nutrients at six different village

Table 3. Grain production (per capita per day) and energy budget (MJ per ha X105) in the form of input:output of wheat and rice in six villages in Garhwal Himalaya

Villages/Region	Crop	Grain Production	Total Input	Total Output	O/I ratio
Tropical					
Ganga Bhogpur	*Triticum aestivum*	1.79	4.41	10.70	2.43
	Oryza sativa	1.00	3.80	6.62	1.74
Kunow	*Triticum aestivum*	0.34	4.24	6.70	1.58
	Oryza sativa	0.14	2.97	3.44	1.16
Sub-tropical					
Bhainswara	*Triticum aestivum*	0.73	6.43	9.07	1.41
	Oryza sativa	0.33	5.97	6.69	1.12
Ghargoan	*Triticum aestivum*	0.26	5.85	5.39	0.92
	Oryza sativa	0.33	5.20	2.87	0.55
Temperate					
Dhaulana	*Triticum aestivum*	0.67	10.65	7.51	0.70
	Oryza sativa	0.48	5.79	6.94	1.19
Chunni khal	*Triticum aestivum*	0.36	7.00	6.21	0.89
	Oryza sativa	-	-	-	-

to increase the air humidity and decrease air temperature in crops and creating favorable conditions for vital processes, which provide higher production to the plant. Maintaining irrigation favoured to microclimate and enhances total crop production.

The average (irrigated and rain fed) grain production of *Triticum aestivum* and *Oryza sativa* reduced with increasing altitude, subsequently phosphorus and potassium also reduced. The reduction in grain production with altitude could be due to these nutrients with altitude. Although pH and soil organic carbon did not show any specific trend with altitude. The increasing altitude reduced the mean annual temperature of the regions. It is assumed that temperate played imported role with altitude which reduced grain production with increasing altitudes. Solar radiation is the main source of photosynthesis. In the lower altitudes solar radiation influenced biomass and yield production with prolonged solar radiation for stem elongation and grain filling while in higher altitude due to low intensity of solar ration negatively influences grain yield. Thus with increasing altitude the reduction in grain production of both the crops may be influenced with the temperature effect. It was interested to not that the tropical region are using fertilizer for the grain production but stilly hilly regions (sub-tropical and temperate) are using only organic fertilizer for grain production.

Thus the study suggests that the high inputs over low outputs have forced people to migrate toward cities in the search of other alternate sources of subsistence. The migration is reducing existing grain production of agriculture from Garhwal Himalaya especially in hilly region. Therefore, special attention need be given to the traditional agricultural systems in other dimensions by providing necessary modern facilities to enhance over all grain production to fulfill the villagers requirement in hill region and also promoting organic farming systems which has high economic values for livelihood security of hilly people thus, traditional agriculture systems and other depended resources could be saved for future.

REFERENCES

1. Bhardwaj RBL, Wright BC. New agronomy for dwarf wheat. Ind. Farm. 1967;17(5):54-8.
2. Chowdhary CR, Pandey SL. Effect of nitrogen and phosphorus with an without irrigation on wheat under shallow water table conditions. Ind. J Agrom. 1975; 20(1):77.
3. Fischer RAJ, Lindt H, Glave A. Irrigation of dwarf whet in Yauai valley of Mexico. Expentl. Agri . 1977; 13(4):353-67.
4. Gopalan GB, Ramasastri V, Balasubraminiam. SC. *Nutritive value of India foods*. National Institute of Nutrition, Hyderabad, India, 1978; 204 pp.
5. Jadhav AS, Shinde AB, Mane KL. Effect of Irrigation regimes at different fertilization levels on wheat varieties. Madras Agri. J. 1981; 3:157-61.
6. Jakson, ML. *Soil Chemical Analysis*. Prentice Hall, Inc., Engle Wood Cliffs, New jersey. 1958; 498 pp.
7. Labrada L. Weed control in rice. Weed management in rice. Auld and Kim (ed). FAO Pl. Prod. And Prot. Paper No. 139 Oxford and IBH Publ. Co. New Delhi 1998; 3 pp
8. Maikhuri RK, Ramakrishnan PS. Ecological analysis of a cluster of villages emphasizing land use of different tribes in Meghalaya in north-east India. Agri. Ecosyst. Environ. 1990; 31:17-37.
9. Misra RD, Sharam KC, Wright BC, Singh VP. Critical stages in irrigation and irrigation requirements of wheat variety 'Larma Roja' Ind. J. Agri. Sci. 1969; 39 (9): 398-406.
10. Mitchell R. *An Analysis of India agroecosystem*. Interprint, New Delhi, India. 1979.
11. Pandey U, Singh, JS. Energy-flow relationship between agro and forest ecosystems in Central Himalaya. Environt Conser.. 1984;11:45-53.
12. Pimentel D, Hurd LE, Bellot AC, Forests ML, Oka ID, Shales OD, Esitman RF. Food production and energy crisis. Sci., 1973;182:443-9.
13. Sati VP. Natural resource conditions and economic development in the Uttaranchal Himalayaa, India. J Mount. Sci. 2005;2(4):336-50.
14. Shafi M., Amin R, Bakht J., Anwar S, Shah WA, Khan MA. Response of Wheat (*Triticum aestivum* L.) To Various Herbicides at Different Growth Stages. Pak. J. Weed Sci. Res. 2004;10 (1-2):1-10.
15. Shekhawat GS, Sharam DC, Bapana SC, Bhangiri BVC. Response of dwarf wheat to nitrogen. Ind. J. Agron. 1975; 23(3): 233-35.
16. Swminathan MS. Science and shaping the future of rice. In Sciece, Technology, and Trade for Peace and Prosperity. Proceedings of the 26th International Rice Conference, 9-12 October 2006, New Delhi, India pp 3-14.
17. Walkey AE, Black JA. An examination of the Degtiga Vett. Method for determining soil organic matter and proposed modification of the chromic acid titration method. Soil Sci. 1934; 37:29.

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