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Energy Budget of Crops and Weed Management to Enhance Crop Productivity in Cold Arid Ladakh Region

M.S. Raghuvanshi[#,*], J.C. Tewari[$], Kamlesh Pareek[$], Stanzin Landol[#], Mohd. Raza[#], and Jigmat Stanzin[#]

[#]*Regional Research Station, Central Arid Zone Research Institute, Leh-Ladakh-194101, India*
[$]*Central Arid Zone Research Institute, Jodhpur-342003, India*
[*]*E-mail: mahendra.raghuwanshi@icar.gov.in*

ABSTRACT

Small scale agriculture is still the predominant characteristic of the Ladakh region. It still has a great role in Ladakh economy. The region produces barley, wheat, vegetables and also involved in rearing livestock. The farming systems are unique and adapted to the harsh environmental conditions of Ladakh. Currently, the largest commercial agricultural produce is vegetable, which is sold in large quantity to defence establishments and as well as in the local market. It was recorded that production remains mainly in the hands of small land owners. In all the surveyed villages, majority of area (75 percent) is under vegetable crops as compared to cereals such as wheat and barley (25 percent). Efforts/ energy (unit in each case= value X 10^5 k cal/ha/year) being put to grow vegetables are significantly higher than the total output and the situation is just reverse in case of cereals. Survey revealed the need of small scale interventions including scientific weed management. From total energy point of view, staple crop production was found to be energy efficient. Even though subsistence-oriented production remains the economic mainstay, livelihood strategies have diversified in the light of growing geostrategic relevance and significant socio-economic changes.

Keywords: Subsistence agriculture; Energetic; Energy budget; Weed control; Potato; Onion

1. INTRODUCTION

Ladakh is a cold desert in trans-Himalaya. The average altitude of human habitation in Ladakh is over 3000 m amsl. Being at high altitude, it suffers from an extremely harsh climate during winter (-30 ºC) and remains cut off for almost seven months i.e. from October-May from rest of the world by surface transportation. Agriculture with harvesting glacier water in the lap of Himalaya has come-up as a small-scale farming system, well adapted to the unique and extreme environment. Households in Ladakh rely essentially on subsistence agriculture based on principal crops such as wheat, barley and potato which is grown during May-October in Ladakh. Potato is consumed as main vegetable during winter season. Huge quantity of potato is also imported to the region as the production is very limited due very limited cultivation and as well as low productivity. In majority of the situations, land holdings are only one to two hectares. Moreover, under the very harsh terrain condition in Ladakh, there is little desire to own large areas of land. Most villages outside the Indus Valley are small and tucked into narrow valleys. Nevertheless, people have utilised water from glacial-fed streams on their stone-built terraces to practice cultivation. Conservation of old land races of cultivated plants, especially of alfalfa, is of global importance. However, weeds not only compete for space and moisture, but also reduce the yield and quality of produce to a significant level.

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Historically, agriculture has been the mainstay of Ladakh economy[1]. Through a complex network of irrigation channels and also through ingenious methods of fertilizing soil, people historically produced more than enough food for their needs[1-4]. The majority are self-supporting farmers, living in small settlements scattered on the high desert. Optimum acreages determined by the size of the family, roughly one acre per working member of the household. It is very interesting that Ladakh did not have suffered from any serious famine[5].

Agriculture in recent years is changing and emerging as an important sector after introduction of new crops, improved technologies on the field of protected agriculture and suitable interventions by the research institution. This region is famous for naked barley, locally known as *Grim*. Fruits and vegetables contribute more than 30 per cent to value of output from agriculture in Ladakh. With the increase in demand for agricultural produce especially, fresh vegetables including potato and onion, the staple food crops like barley and wheat are becoming less important due to subsidies being provided by public distribution system (PDS). This has created a gap which would take years to achieve the desired targets of matching demand and supply. Besides,

tourism sector and army are emerging as main consumer of agricultural produce. During the past few years, the demand for agricultural and horticultural produces has been showing much faster growth. The gap in demand and supply can only be narrowed with interventions at resource poor small farmers. The growth of agricultural sector has been tremendously slow as compared to the flourishing tourism in the region. Subsistence food-grain production in Ladakh is more likely to be used for family consumption than cash income.

The principle crop in Ladakh is barley, occupying two third of cultivated area and rest remain with fast growing varieties of wheat and other vegetables (turnip, potato and cabbage along with other leafy vegetables). The naked barley comes in several varieties appropriate to different soil and climatic conditions, and is often sown in rotation with peas, a nitrogen-fixing crop which contributes to the fertility of the soil in parts. Pulses are raised on a very small scale. Cultivation of grain is supplemented by vegetables and fruit growing. Culturally land is not considered as property but cultivated land is a symbol of status[2]. This is now changing with the emergence of alternative livelihoods resources.

Meeting the requirement of fresh vegetables for the soldiers and the local populace of the remote mountain areas, especially during winter months is a formidable challenge[6]. This region is locked every year from November-May due to heavy deposition of snow on the roads and passes. Air-lifting of the fresh vegetables results in heavy expenditure, which makes the produce unaffordable for the common masses. Army also requires huge quantity of fresh vegetables in the region and spends a substantial amount to import the vegetables from other parts of the country. Including army and other floating population, vegetables are required for a population of about 3.0 lakh in the region. Army requires 37,200 metric ton/year vegetables out of which approximately 17,705 metric ton/year are being locally produced indicating a great gap on demand and supply scenario[3].

2. MATERIALS AND METHODS

A field survey was carried out by Regional Research Station, ICAR- Central Arid Zone Research Institute (CAZRI), Leh at Saboo village to find out the structure and production functions of farming systems and energy budget of crops and also to find out suitable weed management options for enhancing productivity of farmers' fields. Village Saboo is located in 34.1328808°N latitude and 77.6335659°E longitude extending from 3500 to 3745 m altitude. For the purpose, secondary data were collected and randomly 112 farmers (40 percent) were surveyed by developing questionnaire. The data so collected was subjected to compute energy budget of the crops grown. Two crops were also taken for input interventions for understanding the productivity enhancement, using recommended non-chemical and chemical weed management options involving pre-emergence application of recommended herbicides along with hand weeding. Jyoti and Brown Spinach varieties were used for potato and onion, respectively in sandy loam soil. Recommended package of practices were followed in addition to traditional practices of FYM application. Data on weeds and crop parameters were recorded. Being a rain shadow mountain, precipitation is less than 100 mm, scanty and negligible. Weed index (percent), which is an ideal parameter to judge the effectiveness of weed management methods, was used which shows the reduction in crop yield due to presence of weeds in comparison with weed free check.

3. RESULTS AND DISCUSSION

3.1 Crop Productivity and Energy Budget

Village-Saboo is amongst the most populated villages of Leh region. Agricultural fields have been prepared and being maintained since centuries with repeated addition of manures, compensating the loss of organic matter due to erosion and nutrient removal by plants. Crop productivity in Saboo village is presented in Table 1. Seed input in case of barley and wheat is almost 2.5 times higher than the recommended dose. Manure used to fertilize these crops was 200.4 and 242.0 kg ha^{-1}, respectively. Potato and onion involve higher labour costs.

In all the crops of village, manure was a major input

Table 1. Crop productivity of Saboo village, Leh Ladakh

Crop	Seed Input (kg ha^{-1})	Yield output (kg ha^{-1})		Manure used (kg ha^{-1})
		Grain	Straw	
Barley	200.0	528.0	1320.0	200.4
Wheat	283.6	819.5	2104.8	242.0
Pea	260.0	1350.0	450.0	3960.0
Tuber (Mainly Potato)	1720.0	12900	2150.0	5340
Other Vegetables	2.6	612.2	895.5	3900.0
Onion	2.6	342.5	-	3512
Alfalfa (Fresh)	26.4	9784.0	-	3320.8

which accounted for $8.2x10^5$ k cal $ha^{-1}year^{-1}$energy input for barley and $217.5x10^5$ k cal $ha^{-1}year^{-1}$ for potato (Table 2). Total energy input was highest for potato followed by pea. Minimum energy input was recorded for staple crops barley and wheat. It was very interesting that farmers sow wheat and barley and do not carry out any intercultural operations like weeding, etc. Thus, energy input of animal and human was also very low in these crops. From total energy point of view, staple crop production was found to be energy efficient. However, the energy input of pea, potato, onion, other vegetables and alfalfa was much higher than the output. Similar trends in the villages of central Himalaya[7].

Food supplied through the PDS is increasingly replacing locally grown barley as the main staple of the summer diet[8]. Even after being transported from long distances, the barley and wheat are sold for much less price than that grown in Ladakh. This factor discouraged farmers to intensify their local grain production. Diversification of agricultural production toward cash crops by exploiting the so called 'niche advantages'[9], region specificity is

Table 2. Energy budget of different crops in Saboo village, Leh Ladakh

Particular	Barley	Wheat	Pea	Potato	Onion	Other vegetables	Alfalfa
Input							
Human labour	2.4	3.0	6.1	0.4	1.5	2.2	1.8
Dzolabour	3.1	4.3	6.9	2.2	2.4	1.6	0.2
Seed	7.7	11	10.6	16.2	0.1	0.1	1.0
Manure	8.2	9.9	161.3	217.5	143.1	158.9	135.3
Fertilizer	4.0	1.0	-	3.0	3.0	2.0	-
Total	25.4	29.2	184.9	239.3	150.1	164.8	138.3
Output							
Arable crop/commodity yield	20.4	31.6	54.9	121.5	36.8	24.9	92.2
Crop straw/ vegetable residue	43.9	70	4.2	20.2	3.3	8.4	-
Total	64.3	101.6	59.1	141.7	40.1	33.3	92.2
Output: input Ration	2.5	3.5	0.3	0.6	0.3	0.2	0.7

the relatively good climate in summer. However, in general insufficient fertile area under grain crops, and continuous land use change, new food habits, public distribution system, and off-farm income opportunities are the main limiting factors that influence directly the food-grain dependence from outside[10].

Apricots (*Prunus armeniaca* L.) of trans-Himalayan Ladakh are known for its quality and unique characteristics[11]. A number of indigenous apricot genotypes are being grown either as individual trees or small groups of trees. They are marked by great difference in terms of biological and pomological traits. With the climate changing scenario, the incidence of insect-pest and diseases is increasing in the region. Recently, severe infestation of defoliating caterpillar (*Euproctis* spp.) in Dah-Hanu belt, and aphid in Sham and Turtuk belt of Leh district have been observed on apricot and other fruits. Defoliating caterpillar has now become an established pest and causing huge economic loss since 2013 in seven affected villages of Leh district. This economic lose was recorded to be in order of Rs 223.5 lakhs in 2016. Similarly, aphid infestation on apricot in 2016 has resulted in loss of Rs 545 lakhs in Khalsi and Turtuk belt of the district[12].

3.2 CAZRI, RRS, Leh's Preliminary Approaches to Enhance Agriculture Productivity

CAZRI, RRS, Leh has been successful in making farmers aware about the constraints identified and weedy menace in staple and vegetable crops, and their effect on crop productivity. Weed control alone can make significant impact in enhancing crop productivity by 10 to 20 per cent. Problematic and associated weed flora of the region were identified and accordingly small scale interventions such as introduction of hand hoe, herbicides, etc. were carried out. A survey was carried out which indicated that majority of weeds associated with crops constitute of Amaranthaceae, Asteraceae, Poaceae and Fabaceae families[13]. Through various awareness training programmes, the farmers are now getting aware of weed menace in their crops. Efforts were designed to formulate easy-go and adoptable interventions in staple and vegetable crops. Wheat, barley, potato, onion and other vegetables were selected for direct and simplified interventions for resource poor farmers in the light of overpriced labours in Ladakh region. Looking to the interest of farmers, demand for herbicides have grown more than before where the labours are being paid Rs. 500 per day. Sustainability comes by restored technical know-how with better technology transfer with ensured quality seed/ input supply.

Field trials showed that in onion, var. Red Coral performed significantly better. Hand weeding has yielded significantly higher bulb yield of 20.31 t/ha which was at par to chemical weed treatment of pendimethalin (796 ga.i./ha 38 percent EC) (14.95 t/ha), pendimathalin (1.0 kg a.i./ha 30 percent EC) (18.76 t/ha) and oxyfluorfen (250 g a.i./ha 23.5 percent) (17.50 t/ha) as compared to weedy check (2.83 t/ha) (Table 3). In case of potato, maximum tuber yield was recorded under black polythene mulch (21.65 t/ha) followed by hand hoeing 30 days after sowing (19.13 t/ha). It was recorded that more yields from potato can be expected if weeds are suppressed using black polyethylene mulch between the rows of potato followed by hand hoeing and earthing-up during the critical period of crop-weed competition. Weed index (percent) also showed that the weedy condition and farmers' method have resulted in almost 40 to 51 per cent reduction in the tuber yield. The weed free plot recorded significantly higher tuber yield over chemical treatments. These results are in conformity with earlier findings[14]. Hand weeding + earthing up at 25 days recorded 16.99 t/ha yield which is 64 and 100 per cent more than weedy (control) and farmers' method, respectively (Table 4). Such efforts could help in reducing gaps in

crop and vegetable production.

4. CONCLUSION

Table 3. Effect of different herbicides on weeds and yield of onion (var. Red coral) in Ladakh

Treatments	Fresh weight ($g.bulb^{-1}$)	Diameter ($cm.bulb^{-1}$)	Bulb Yield ($t.ha^{-1}$)
Pendimethalin 30% at 1.0 kg a.i.ha^{-1}) as pre-plant incorporation	0.16	22.67	18.763
Pendimethalin 38.5%796 ml a.i. ha^{-1}as pre-plant spray	0.15	21.67	14.95
Oxyfluorfen 23.5% 250 ml a.i. ha^{-1} Pre-plant spray	0.091	19.33	17.50
Hand weeding	0.084	19.33	20.31
Weedy	0.006	6.0	2.83

Table 4. Effect of organic weed management options on weeds and yield of potato in Ladakh

Treatments	Weed density ($No.m^{-2}$)		Weed dry weight ($g.m^{-2}$)		WCE (%) 60 DAS	Tuber yield ($t.ha^{-1}$)	Weed index (%)
	30 DAS	60 DAS	30 DAS	60 DAS			
Weedy check	8.8 (76.67)	9.39 (88)	3.91 (15.23)	4.8 (23)	-	5.70	72.43
Hand hoeing (30 DAS)	5.04 (26.3)	5.74 (33)	2.89 (8.33)	3.39 (11.67)	49.26	19.13	11.65
Black mulch	4.9 (24)	6.25 (39)	3.20 (10.2)	3.6 (13.06)	43.21	21.65	-
Metribuzin 500 g a.i. /ha	4.6 (21.33)	5.57 (31)	3.3 (10.9)	3.67 (13.67)	40.56	18.81	13.13
Earthing-up at 30 DAS	3.3 (11)	3.89 (15)	2.7 (7.2)	2.78 (7.83)	65.95	18.89	12.76
CD (P-0.05)	1.24	0.17	1.12	0.746	-	3.77	-

Data gathered during the present investigation indicated that the production of staple crop wheat and barley are the energy efficient. However, vegetable production is not energy efficient. Moreover it appears that the area under staple crop is gradually decreasing or remains constant for several years as farmers are preferring cash crop like potato, onion, and other vegetables. Recent change in socio-economic has resulted in the shift in cropping pattern as well as increased use of fertilizers along with seeds of high yielding varieties. Adoption of suitable weed control options along with use of appropriate fertilisation and use of high yielding crop varieties including improved production packages can enhance the productivity to a significant level.

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CONTRIBUTORS

Dr M.S. Raghuvanshi is working as Scientist (Agronomy) at Regional Research Station, ICAR-Central Arid Zone Research Institute (CAZRI), Leh-Ladakh. He has been awarded best worker award and Certificate of appreciation at Directorate of Weed Research (DWR), Jabalpur for brining recognition to institute. He has edited 6 important DWR official publications, published 20 national research papers and 11 chapters, 4 review papers and many popular articles in the field of weed science and cold arid regions.

Dr. J.C. Tewari was Principal Scientist (Forestry) and Former Coordinator, Regional Research Station, Leh and Cold Arid Network at ICAR-Central Arid Zone Research Institute (CAZRI), Jodhpur. He has published more than 200 research papers and published/ edited 8 books of international repute in the field of Agroforestry. He is a recipient of Doreen Mashler Award-2004 for his work on watershed development; Appreciation Certificate of DG, ICAR/ National Director, World Bank funded mega project, NAIP -2012, for his work on *Prosopis juliflora* value chain; and Outstanding Partnership Award –Asia-2015 of ICRISAT for his work on livelihood improvement in dry land production systems.

Mr. Kamlesh Pareek is Senior Research Associate ICAR-Central Arid Zone Research Institute (CAZRI), Jodhpur, having specialisation in the field of Bioinformatic.
His contribution towards the study was data collection.

Ms Stanzin Landol is Technical Assistant at Regional Research Station, ICAR-Central Arid Zone Research Institute (CAZRI), Leh, having specialisation in the field of Forestry and Agro-Forestry, completed her post-graduation from SKUAST-K and SKUAST-J universities.
Her contribution was towards the study was data collection and crop stage monitoring.

Mr Mohd. Raza is Field Assistant at Regional Research Station, ICAR-Central Arid Zone Research Institute (CAZRI), Leh, having specialisation in the field of Seed Technology.
His contribution towards the study was data collection at Leh.

Mr Jigmat Stanzin is a Senior Technical Officer at Regional Research Station, ICAR-Central Arid Zone Research Institute (CAZRI), Leh-Ladakh and BSc Forestry, MSc Agroforestry, one year Diploma in Mechanical Wood Science from IPRITI Bangalore under Ministry of forest.
His contribution towards the study was data collection and compilation of the paper material and references.