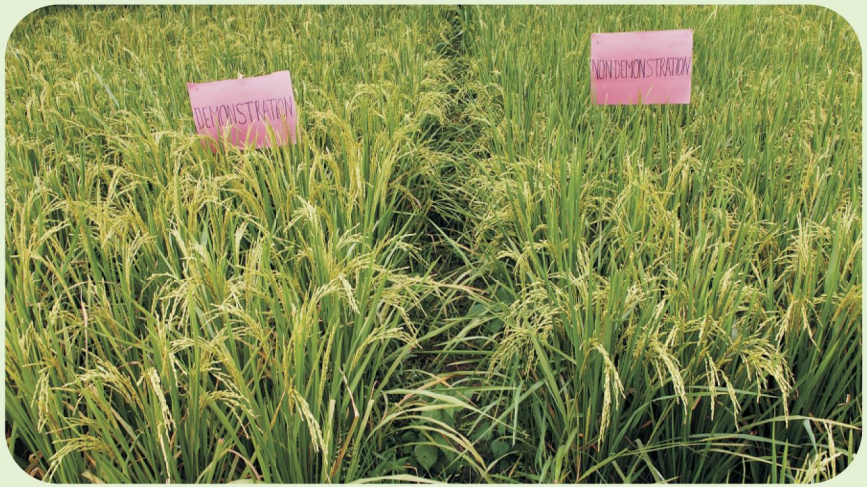
Balanced and Integrated Nutrient Management in Dominant Cropping Systems for Enhanced Crop-Water Productivity in Farmer's Field of North-West Lower Himalayan Region



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FOREWORD

Sole cropping, low cropping intensity and use of only organic sources of fertilizers in the north-western Himalayan states has led to decline in yield of crops. Fertilizer recommendations for sole cropping may not meet the nutrient requirement of component crops in the inter-cropping system. Further, imbalanced nutrient application has been degrading soil health and water productivity. Thus, enhancing and sustaining the productivity in the north-west Himalayan region is a major challenge as agriculture is practiced under mildly sloppy lands and outward level terraces without due care of soil and water conservation. Extreme imbalance of inorganic fertilization (N: P: K 15.5:5.0:1) against ideal consumption ratio (4:2:1) and high organic *vs* inorganic (9:1) have exhibited very low factor productivity and sustainability index. The north-western Himalayan soils comprising of varying slopes cause severe land degradation with huge loss of soil, water, nutrient and productivity. Integrated nutrient management not only improves grain quality but also enhances soil heath. Balance fertilization with higher canopy cover reduces soil erosion which in turn increases productivity, soil health and better water balance.

I am confident that the balanced and integrated nutrient management technologies covered in this brochure after demonstration in Dehradun (UK) and Sirmour districts (HP) at farmers' fields will not only help in getting additional revenue to the farming community but also in preventing land degradation and improving soil quality.

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Balanced and Integrated Nutrient Management in Dominant Cropping Systems for Enhanced Crop-Water Productivity in Farmer's Field of North-West Lower Himalayan Region

INTRODUCTION

- Exclusive use of organic sources, sole cropping and low cropping intensity in the north-west Himalayan states are decreasing the yield sustainability and factor productivity in all cases. Fertilizer recommendations based on sole cropping may not meet the nutrient demand of component crops in the intercropping system. Moreover, imbalanced fertilization of N: P: K (15.5:5.0:1) against ideal consumption ratio of 4:2:1 nutrient application in exhaustive dominant cropping system has been degrading soil health.
- Integrated Nutrient Management (INM) alone can enhance 25-50% water holding capacity of soil which could reduce water loss through percolation and it also increases water use efficiency (WUE) by 15 to 25%. System of Rice Intensification (SRI) which requires moist surface soil irrigation schedule instead of continuous ponding of 5-10 cm can save 20-25 % water.
- Imbalanced fertilization induces scanty canopy cover which causes higher soil erosion and makes the cropping system uneconomical and unsustainable.
- Balanced fertilization reduces soil erosion which in turn increase productivity, soil health and better water balance.
- Hill and mountain agriculture evolved over centuries with the application of Farmyard Manure (5-15 tonnes ha^{-1}) along with inorganic NPK application hardly exceeds 20.0 kg $ha^{-1}yr^{-1}$ as against 115.0 kg $ha^{-1}yr^{-1}$ national average of which potassic fertilizer application is virtually nil.

TECHNOLOGY DEVELOPED

The technology basically consists of cropping system, intercropping and introduction of short duration cultivar as well as new method of rice cultivation popularly known as system of rice intensification (SRI) on rainfed and limited irrigation condition with integrated nutient management. Four interventions listed below were demonstrated in farmer's fields.

1. Maize + Cowpea (1:2) – Wheat with INM (Recommended NPK + FYM @ 5 t ha^{-1}).
2. Maize – Wheat + Mustard (9:1) with INM (Recommended NPK + FYM @ 5 t ha^{-1}).
3. Maize – Potato – Onion (Recommended NPK + FYM @ 5 t ha^{-1}).
4. Paddy – Wheat with INM (Recommended NPK+ $ZnSO_4$ @ 10.0 kg ha^{-1} + FYM @ 5 t ha^{-1}) as well as SRI + INM rice – wheat.

TECHNOLOGY IMPLEMENTATION

Field Preparation

- Ploughing should be done on the onset of the monsoon prior to sowing of *kharif* crops.
- For the SRI paddy crops, nursery should be raised in the month of June-July depending upon monsoon and seedlings should be 9-12 days old before transplanting.
- For SRI paddy, plant to plant and row to row distance should be kept at 20 x 20 cm.
- Weeding of paddy crops should be done by cono weeder and weed biomass should be left in the field.

Fertilizer Application

- Respective FYM doses for all the crops should be applied at the time of land preparation.
- Fertilization in case of SRI paddy should be preferably organic sources.

- The recommended NPK dose for the crops under demonstration were as follows:

Crops	Doses (kg ha^{-1})		
	N	P	K
Maize (rainfed)	90	60	40
Wheat (rainfed)	60	40	30
Wheat (irrigated)	120	60	40
Rice (irrigated)	120	60	40
Potato (irrigated)	120	80	150
Onion (irrigated)	60	40	40

- Half of the recommended dose of N and full dose of P and K fertilizers should be applied at the time of land preparation and rest of the N fertilizer should be applied at the respective critical growth stages of the crops.

Water Management

- For irrigated wheat crop, irrigation was given at critical growth stages of pre-sowing, panicle initiation/crown root initiation, active tillering and grain filling and similarly to the irrigated rice crop.
- Moist surface soil (hair cracks) irrigation scheduling was followed for SRI rice field.
- Limited irrigations (4-6 nos.) were applied to potato crops at critical growth stages on residual soil moisture.
- For onion limited irrigation (6-8 nos.) were applied at critical growth stages depending upon winter rains.

Area of Implementation

States	Districts	Blocks	Villages
Uttarakhand	Dehradun	Sahaspur and Vikasnagar (Dehradun)	Dhaki, Dhakonwali, Vikasnagar
Himachal Pradesh	Sirmour	Paonta Saheb	Danda

A total of 19 farmers were selected for all the demonstrations having one ha of land for each technology.

PRODUCTION & CONSERVATION EFFICIENCY OF INM

Demonstration 1 and 2 (Sahaspur Block)

The following interventions were demonstrated in the farmer's field in the Sahaspur block:

Intervention 1 : Maize + Cowpea (1:2) - Wheat with INM (Recommended NPK + FYM @ 5 t ha^{-1})

Pre-implementation Scenario : Farmers of this region usually grow maize followed by wheat with imbalanced fertilization under rainfed conditions having light textured soils, poor in fertility status and low in water holding capacity.

Post- implementation Scenario : Inter-cropping of cowpea with maize along with INM application for successive two years increased the yield to the tune of 65.9% and 45.5% for maize and wheat, respectively (Table 1). Cowpea inter-cropping (Photo 1) not only provided additional vegetable (green pods) but also improved the soil quality by 15.8% and profile water use under rainfed condition.

Table 1 : Yield and net return as affected by INM and inter cropping/cropping sequence in the farmer's field

Inter-vention	Crops	Yield (kg ha^{-1})			Net return (₹ ha^{-1})		
		C	T	Increase (%)	C	T	Increase (%)
1	Maize	2213*	3675*	65.9	4448	11690	162.8
	Wheat	1125	1640	45.5	3176	6149	88.4
2	Maize	1940	2755	42.0	3248	8658	166.3
	Wheat	1310**	1929**	47.0	4455	9041	104.5
3	Maize	1954	2860	46.4	3361	9135	171.8
	Potato	17100	23500	33.3	9775	19250	96.9
	Onion	12050	15100	25.3	38700	51050	31.6
4 (a)	Paddy	4625	6225	35.5	34244	46120	34.7
4 (b)	Paddy (SRI)	4625	6330	39.9	34244	47310	38.1
	Wheat	2350	3150	34.0	15992	24869	55.8
	Overall				**40.7**		**90.1**

C - Conventional method; T - With technology;

* Maize equivalent yield; ** Wheat equivalent yield

Photo 1 : Maize + cowpea (1:2) intercropping with INM

Intervention 2 : Maize – Wheat + Mustard (9:1) with INM (Recommended NPK + FYM @5.0 t ha^{-1})

This technology was demonstrated in Dhaki village of Sahaspur block, Dehradun district of Uttarakhand among 3 farmers in 1 hectare land. Intercropping of mustard with wheat along with INM application for successive two years revealed that yield increased by 42.0% for maize crop whereas it increased by 47.0% for wheat crop (Table 1). Mustard intercropping (Photo 2) not only provided additional oil seed yield but also improved the soil quality by 17.2% and profile water use under rainfed condition (Table 2).

Photo 2 : Wheat + Mustard (9:1) intercropping with INM

Table 2 : Water use efficiency as affected by INM and inter cropping/ cropping sequence in the farmer's field

Intervention	Crops	Water use efficiency (kg ha^{-1} mm)		
		C	T	% increase
1	Maize	3.19	5.60	75.8
	Wheat	5.30	8.31	56.6
2	Maize	3.00	4.34	44.5
	Wheat	6.33	9.66	50.3
3	Maize	3.09	4.52	46.0
	Potato	53.70	76.50	42.4
	Onion	18.87	25.45	34.9
4 (a)	Paddy	6.08	8.44	38.9
4 (b)	Paddy (SRI)	6.08	8.99	47.9
	Wheat	6.95	11.19	61.1
	Overall			**44.7**

Demonstration 3 (Paonta Saheb Block)

Pre-project Scenario : Farmers of this region usually grow maize followed by onion with imbalanced fertilization under limited irrigation conditions with low productivity and less remuneration.

Intervention 3 : Maize-potato-onion (Potato in maize-onion traditional sequence) with INM (Recommended NPK + FYM @ 5 t ha^{-1}).

This intervention was demonstrated in Danda village of Paonta Saheb block of Sirmour district of Himachal Pradesh among 11 farmers in 1 hectare land. Introduction of short duration potato cultivar with INM application for successive two years revealed that yield of maize crop increased by 46.4% whereas it increased by 33.3% for potato crops. Onion crops showed an increase of 25.3% (Table 1). Potato introduction in maize - onion traditional sequence (Photo 3) not only provided additional yield but also improved the soil quality by 18.8% and profile water use under limited irrigation condition.

Demonstration 4 (Vikasnagar block)

Pre-project Scenario : The soils of the farmer fields were medium textured, medium in fertility parameters and low in water

Photo 3 : Bumper crop of potato with INM

holding capacity. Farmers of this region usually grow paddy followed by wheat with imbalanced fertilization with frequent irrigation.

Intervention 4 : (a) Paddy-wheat with INM, and (b) System of Rice Intensification (SRI) Paddy - wheat with INM (Recommended NPK+ $ZnSO_4$ @ 10.0 kg ha^{-1} + FYM @ 5 t ha^{-1})

This intervention was demonstrated in village Mehuwala of Vikasnagar block of Dehradun district of Uttarakhand among 3 farmers in 1 hectare land. Two years average data of demonstration revealed that the yield increased by 35.5% for paddy crop whereas it increased by 34.0% for wheat crop (Table 1). Paddy raised adopting system of rice intensification (Photo 4) produced more or less same yield (only 4.4% higher) and net return but gave higher water use efficiency by 8.0% (Table 2) compared to INM paddy which saved 80-90 mm of irrigation water.

ECONOMICS

There was a significant effect of INM technology on net return of crop rotations over conventional farming (Table 1). The average two years increase in net return with INM treatments over conventional farming ranged from 31.6 to 171.8%. The highest net return from the individual crops with INM application

Photo 4 : Paddy (SRI) with INM

was observed in onion crops (₹ 51,050 ha^{-1} yr^{-1}) in maize - potato - onion rotation whereas lowest from wheat (₹ 6,149 ha^{-1} yr^{-1}) in maize + cowpea - wheat rotation. On an average 90.1% increase in net return was observed with INM technology over conventional farming practices (Table 1) of which maize - potato - onion sequence showed maximum net return to the tune of ₹ 7,943 ha^{-1} yr^{-1}.

SCOPE OF APPLICATION AND GENERAL REMARKS

Balanced and integrated nutrient management along with intercropping technology is applicable to the states of Uttarakhand, H.P. and J&K. This technology can be adopted by the farmers of hill and mountain agro-ecosystem specifically in medium to light textured soils to conserve natural resources. The technology is beneficial particularly in increasing water productivity, checking soil degradation in respect of nutrient mining and in build up of organic matter leading to enhancing productivity.