Horticulture Based Farming System in Mizoram: An Alternative to Jhum Cultivation

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Abstract

In Mizoram, Jhum cultivation (shifting or slash-and-burn cultivation) is practiced in 40089 ha area which is about 38.64 % of net sown area. The Lushai terrain of state is endowed with wide agro-climatic conditions and sufficient genetic diversity; which provide virtuous scope for horticultural based farming system to replace non-productive and destructive Jhum practices by espousing soil conservation measures, in-situ moisture conservation, vermicomposting and nutrient management, crop diversification, use of high yielding varieties, proper crop rotation and orchard management, and high-tech horticulture. Most suitable horticultural crops are mandarin, banana, passion fruit, pineapple, areca nut, ginger, turmeric, bird's eye chilli, chow-chow, cabbage, French bean, cowpea, vegetable mustard, Chinese kale, tomato, radish, pumpkin, brinjal, African eggplant, *Solanum ferox, S. tarvum*, ash gourd, okra, cauliflower, rice bean, Colocasia, Anthurium, rose and orchids. The ICAR-RC-NEH Region has successfully demonstrated the various technologies at own Farm and farmers' field having significant impact on soil-water conservation and enhancing the Farm productivity such as soil and water conservation practices (construction of contour trenches, bench terraces, half-moon terraces, drainage line treatments and water harvesting structures); adopting high yielding varieties and potential local genotypes (15-55 %); mulching with local dry grasses (15-45 %); vermicomposting, micronutrient and INM (10-30 %); leaf and branch pruning (12-25 %); and protected nursery management and cultivation (25-450 %). Horticulture based farming system in Mizoram would certainly reduce the area under Jhum cultivation, and improve Farm productivity, income and sustainability.

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Introduction

Mizoram is 23rd state of India located at 21º58' to 23º35' N latitude and 92º15' to 93º29' E longitude which is surrounded by Tripura, Assam and Manipur in north-frontier regions; Bangladesh in west; and Mayanmar in east and south. The undulated topography of Lushai hill has varied altitude ranged from 21 to 2157 m above the mean sea level (average 920 m) with an annual rainfall of 2000-3200 mm. The upper part of the hills are predictably cold and cool during the summer, while the lower reaches are relatively warm and humid. The storms break out during March-April, just before or around the summer. During winter, the temperature varies from 11-21 ºC; and in the summer, it varies between 20-29 ºC. The entire area is under the direct influence of the South-West monsoon. It rains heavily from May to September. The soils of Mizoram are dominated by sedimentary formation. These are generally young immature, mostly developed from parent materials such as farraginous sandstones and shale. The soil in the hills are strongly acidic in reaction, where as the soils in alluvial deposits are less acidic in nature. The surface soils of the hilly terrains are dark, highly leached and poor in base, rich in iron and have pH values ranging 4.5 to 5.5 (highly acidic). Soils of the valley flats lands are brown to dark brown, poor in bases, moderately acidic with pH ranging from 5.5 to 6.0. Total population of state is 10.91 lakh and the decadal growth rate during 2001-2011 is 22.78 %, the literacy rate is 91.6 %, and the population density is 51.7 people/ km^2 in 2011 (Anonymous 2009). Majority of the population, approximately 62 %, depends on agriculture and allied sectors for their livelihood. The total geographical area is 2108700 ha, of which net sown area constitutes only 4.92 % (103835 ha) and the cropping intensity is about 110.98 %. Presently 40089 ha land is under Jhum cultivation (shifting or slash-and-burn cultivation) and forest cover is 75.6 % of the total area (Table 1, Anonymous 2009). Jhum cultivation, main method of cultivation in Mizoram, is a primitive practice of cultivation in

the States of North Eastern Hill Region and tribal areas of India, and people involved in such cultivation are known as Jhumia. The practice involves first clearing of vegetation/forest cover, drying, burning it before onset of monsoon, and growing crops on it. After harvest, this land is left fallow and vegetative regeneration is allowed on it till the land becomes reusable. Initially, Jhum cycle was long (15-25 years), but it reduced to 5-6 years which pose the problem of land degradation and threat to ecology. Although Jhum cultivation is destructive for environment and non-remunerative for the cultivators; the vast majority of rural and semi-urban households have to resort to this primitive cultivation practice (Singh et al. 2013b). Supported by the wide agro-climatic variation of Mizoram and good genetic diversity (Singh et al. 2010b, Singh et al. 2011d, Singh et al. 2012 and Singh et al. 2013a), there is good scope for an alternative farming system based on horticultural crops (with their Mizo name in parentheses) such as fruits like mandarin (Serthlum), banana (Balhla), passion fruit (Sapthei), pineapple (Lakhuihthei), and areca nut (Kauhva); vegetable crops such as chow-chow (Iskut), cabbage (Zikhlum), French bean (Bean), cowpea (Behlawi), vegetable mustard (Antam), Chinese kale (Fren antam), tomato (Tomoto), radish (Buluih), pumpkin (Mai), brinjal (Bawkbawn), African eggplant (Satinrem), *Solanum ferox* (Samtawk), *S. tarvum* (Samtawkte), ash gourd (Maipawl), okra (Bawrhsaiabe), cauliflower (Parbawr), rice bean (Bete) and colocasia (Bal); spices- ginger (Sawhthieng), turmeric (Aieng), and bird's eye chilli (Hmarcha), and flowers like anthurium, rose (Rose pangpar) and orchids (Nauban).

Table 1: Land use statistics of Mizoram ('000 ha).

S. No.	**Particular**	**2007-08**	**2008-09**
1	Geographical area	2108.700	2108.700
2	Reporting area for land utilization statistics	2108.700	2108.700
3	Forest area	1593.700	1593.700
4	Not available for cultivation (a+b)	134.050	133.000
	a) Land put to non-agricultural use	125.430	124.000
	b) Barren and uncultivable land	8.620	9.000

5	Other uncultivated land excluding fallow land (a+b+c)	77.209	67.226
	a) Permanent pasture and other gazing land	5.230	5.250
	b) Land under miscellaneous tree-crops (not included in net area sown)	66.749	51.976
	c) Cultivable waste	5.230	10.000
6	Fallow lands (a+b)	210.928	210.939
	a) Fallow lands other than current fallows	165.980	170.850
	b)Current fallows (Jhum land)	44.947	40.089
7	Net sown area	92.813	103.835
8	Total cropped area	102.903	115.236
9	Net irrigated area	9.446	11.022
10	Area under horticulture	39.792	41.872

Source: Statistical Abstract of Mizoram 2009

There is an urgent need to improve the Jhum cultivation practices through horticulture based farming system by adopting land development/ soil conservation measures, in-situ moisture conservation, vermicomposting and nutrient management, crop diversification, use of high yielding varieties/ genotypes, proper crop rotation and orchard management, and high-tech horticulture; which will ultimately ensure the nutritional and livelihood security.

A. Land development/ soil conservation measures

The concept of land development/ soil conservation, now–a–days, has been expanded to mean protection of the soil against physical loss and water conservation to minimize the soil-water erosion (Singh and Satapathy 2011). Therefore, the effective management of land and water resources aimed at obtaining optimum and sustained benefit without impairing and degrading them. These could be achieved effectively by adopting soil and water conservation practices such as construction of contour bunds, contour trenches, bench terraces, half moon terraces, drainage line treatments and water harvesting structures.

Contour bunds are mechanical (earth made) barriers created across the slope following the line of contour to conserve the rainfall in-situ (low rainfall region) and safe disposal of water (high rainfall region) by longitudinal gradient deviation (0.4-0.5 %) in contour line and grassed

waterways. The graded bunds are made along this line. On steep slopes, these bunds are created by way of excavating parabolic channel (30 cm top width × 20 cm deep) along the grade line and the dugout soil is placed in a form of bund at the downstream of the channel. The height of bund should be such that it can allow maximum 30 cm impounding of water near the bund. In the region normally 40-45 cm height is appropriate. Theoretically, bunding is suitable for lands with slopes ranging from 2 to 10 % but experiences indicate that it can be adopted for land with slope up to 30%. Moreover, counter trenches are a type of depression or micro-pit constructed over the land surface along the contour line in order to prevent soil erosion and to absorb rainwater. Generally, contour trenches, of size 30 × 30 cm at 1 to 2 m vertical interval, are constructed on hilly lands having >15 % slopes with vegetative supports for forestry and horticulture land uses.

Bench terraces are flat beds constructed across the hill slopes and along the contour lines with half cutting and half filling. They serve as barriers to break the slope length and also reduce the degree of slope. On sloppy hills, agricultural practices can effectively be performed on these bench terraces. The terraces, generally, are made on hills up to 33 % slopes; but it is also feasible up to 40-50 % slope. The vertical interval of such terraces should not be more than 1.0 m. Such measures can be adopted where soil depth is more than 1 m. Requisite slope for risers are usually 1:1 (riser to batter) to be maintained for the vertical drops of the terraces. The half-moon terraces are constructed by cutting land surface in the shape of half-moon to create circular level bed having basin of 1.0-1.5 m diameter. The basin may also have inward slope. These are constructed for planting the saplings of fruit crops as well as trees in horticulture and agro-forestry land use system. This type of terraces is made at a distance of planting spacing. Half-moon terrace helps in retaining soil fertility, moisture, and added fertilizers and manures for healthy growth of the plant.

In high rainfall area, safe disposal of runoff water is very important for safety of any terrace system. The main function of grassed/ vegetative waterways is to drain out excess runoff from the

field at non-erosive velocity. It helps to protect land against rill and gully erosion. A waterway is constructed according to a proper design. Turfs or sod of perennial grasses; resistant to drought, erosion and submergence; should be established to protect the channel section against any kind of erosion. The rainwater could be collected and stored by constructing ponds, storage tank, jalkund, etc. by farming community as per their annual water requirement, economic conditions, available Govt. subsidy, feasibility, etc. The surface lining of ponds should be done either by clay soil or low land soil to reduce the percolation of water, especially where the pond soil is porous in nature. The jalkund is low cost technology which is made up of either polythene lining material or silpolin; but there is always chance of leakage of water, if the plastic surface is damaged by any means, i.e. biological, mechanical, chemical, etc. The water storage tank of various sizes could be constructed, especially 50 % underground to enhance the longevity of tank. A tank size of 10×10×5 m contains 5,00,000 litre water which is sufficient to supply regular water, through drip or along with mulching, in one ha of mandarin or passion fruit orchard from November to March (Singh and Pathak 2011).

B. **In-situ moisture conservation**

The protection of soil moisture where it is available is known as in-situ moisture conservation which could be practiced efficiently by growing cover crops (live mulch) and mulches, especially organic ones. These are not only conserving the soil moisture, but also reducing the land degradation. The indigenous crop of Mizoram is rice bean, French bean, cowpea, etc. additionally, black gram, green gram and dhaincha are also very effective for cover cropping. In most parts of Mizoram and North East Hill Regions of India, forest biomass and crop-plant residues are readily available in plenty which could be utilized as mulch. These organic mulches are readily available, economically sound, ecologically safe and eco-friendly. Mulching is the process or practice of covering the soil surface to conserve the water, and make more favourable

conditions for plant growth and development. Mulch, in technical term, means the materials used for covering of soil. The organic mulches such as grasses, crop/ plant residues, leaf, straw, dead leaves and compost have been used for centuries. While during the last 60 years, the advent of synthetic materials/ polythene sheets (black, transparent, yellow, etc) has altered the methods and benefits of mulching. Well dried organic mulch of 4-5 cm thickness is generally used 25-30 days after sowing/ transplanting (DAS or DAT). Mulch provides a better soil environment; stimulates microbial activity; enhances oxygen availability to roots; moderates soil temperature; increases soil porosity and water infiltration during intensive rain; increases nutrient availability; reduces evaporation, fertilizer leaching and soil compaction; controls weeds, runoff and soil erosion; and increases plant growth, yield and quality (Rashidi et al. 2009, Singh et al. 2011e). Despite lot of positive effects of mulching, there are few limitations too: incidence of rodents, chance of fire hazard, and termite problem due to excessive rain. The case studies on effects of mulching at ICAR Kolasib and ICAR Barapani reveal the beneficial impact of mulching in various horticultural crops:

Tomato

Effect of mulching with organic mulch in tomato hybrid Avinash-2 was evaluated during the season 2008-2009. Locally available organic mulch was collected and utilized for experimentation. Although the crop growth, yield and fruit quality was found to be better in T3, T4 and T5 treatments (Table 2), yet the treatment T4 was the best as it saved almost 70 % water.

Table 2: Effect of mulching and watering on growth, yield and quality of tomato

Treatment	Plant height (cm)	Stem thickness (mm)	Fruit size (cm^2)	No. of fruits/ plant	Single fruit weight (g)	Fruit yield (kg/ plant)	Damaged fruit (%)	TSS (^oBrix)
T1	72.6	12.6	22.0	21.4	43.8	0.933	13.5	4.3
T2	90.1	16.3	25.4	34.1	56.4	1.911	9.0	4.3
T3	99.4	16.0	30.6	37.1	83.1	3.081	22.4	4.3
T4	103.9	17.1	33.2	41.0	89.9	3.682	10.8	4.7

T5	105.2	15.3	33.8	43.4	92.1	3.995	12.4	4.6
SE	3.6	NS	1.72	2.1	2.4	0.143	1.835	NS
LSD at 5%	11.7	3.9	5.60	6.9	8.0	0.468	5.984	0.8

(T1: Non-mulch and no irrigation; T2: Mulching and no irrigation; T3: Irrigation need based; T4: Mulching and 30 % irrigation; T5: Mulching and 60 % irrigation)

Broccoli

Three treatment combinations: without mulch and need based irrigation (T1), with mulch and 30 % irrigation (T2) and with mulch and 70 % irrigation (T3) were tested. Locally available dried grasses (Farm wastes and cattle leftover fodder) were used as mulch. Twenty-five days old seedlings of hybrid 'Pushpa' were transplanted during 2nd week of November 2008. The treatment with mulch and 70 % irrigation (T3) treatment was found to be better in respect of head weight, yield and other yield attributing traits (Table 3) which is also at par with T2 (with mulch and 30 % irrigation). The result reveals that broccoli cultivation would profitable by practicing mulching with 30 % irrigation (T2) which saves water up to 70 %.

Table 3: Effect of mulching and watering on yield and yield attributing parameters of broccoli

Treatment	Gross plant weight (g)	No. of leaves	Head weight (g)	Leaf weight (g)	Harvest index (%)	Post-harvest life (day)	Maturity (day)	Yield (q/ ha)
T1	910	13.7	272	35.2	29.6	5.8	68.5	115.7
T2	1156	13.4	309	51.6	26.8	7.8	76.3	131.4
T3	1190	14.5	341	50.0	28.7	7.9	79.8	144.9
Avg	1085	13.9	307	45.6	28	7.2	74.9	130.7
LSD at 5%	69	NS	34	5.4	NS	0.9	8.4	14.3

French bean

An experiment with 10 treatment combinations of mulching, vermicompost and fertilizer (Table 4) was carried out in French bean cv. Arka Komal at ICAR Complex, Kolasib, Mizoram during 2nd week of November. The 100 % RDF (Recommended dose of fertilizer) contains NPK @ 30:50:40 kg/ ha and 100 % VC (Vermicompost) has vermicompost @ 5 t/ ha. All the treatments received only 50 % irrigation. A 5 cm thick mulch of dried grasses and crop residues were used for mulching at 25 days after sowing.

Table 4: The details of treatment combinations

Treatment	Treatment combination		
	RDF (%)	Vermicompost (%)	Mulch
T1	100	-	-
T2	100	-	M
T3	75	25	-
T4	75	25	M
T5	50	50	-
T6	50	50	M
T7	25	75	-
T8	25	75	M
T9	-	100	-
T10	-	100	M

All the growth and yield parameters were generally higher in mulched plots as comparison to non-mulched plots (Table 5). Nevertheless, nodule numbers on the roots were reduced significantly by application of mulch. There is positive impact of application of vermicompost on growth, nodulation and yield of French bean, but lower dose of fertilizer and higher dose of vermicompost had negative effects. The T-5 treatment (50 % dose of each fertilizer and vermicompost) was found to be very suitable for getting higher yield as well as growth in both mulched and non-mulched treatments.

Table 5: Effects of mulching, vermicompost and fertilizer and on growth, nodulation and yield

Treatment	Days to 50% germination	Shoot length (cm)	No. of nodule	Leaf area (cm^2/ leaf)	No. of pod	Pod weight (g)	Pod length (cm)	Pod yield (q/ ha)
T-1	67.0	38.6	28.1	19.4	12.2	5.7	10.5	75
T-2	70.3	40.9	25.6	24.5	13.2	5.9	11.6	83
T-3	66.3	39.8	28.6	25.2	14.2	6.1	12.4	96
T-4	70.3	45.8	25.6	36.9	15.3	6.9	14.8	120
T-5	69.0	38.8	28.3	23.7	16.3	7.1	13.1	118
T-6	72.0	51.2	26.4	31.6	15.2	8.2	16.2	128
T-7	68.3	46.6	29.1	32.7	13.4	6.3	12.3	89
T-8	71.0	55.4	25.7	40.6	15.1	7.2	12.9	117
T-9	69.7	46.4	25.6	32.3	11.6	5.6	10.9	71
T-10	73.0	49.7	24.3	32.1	12.6	5.9	11.2	81
Avg	69.7	45.3	26.7	29.9	13.9	6.5	12.6	98
LSD at 5%	2.5	1.8	3.1	4.0	1.4	0.7	0.8	18.3

Capsicum

The experimental trial on mulching was designed with the objective to examine the influence of irrigation level and organic mulching on growth and yield of capsicum. Five treatment combinations (T-1: 100 % irrigation + No mulch; T2: 75 % irrigation + Mulch; T3: 50% irrigation

+ Mulch; T4: 25 % irrigation + Mulch; and T5: 50 % irrigation + without mulch) were taken at ICAR, Kolasib, Mizoram during 1st week of November 2009. One month old seedlings of capsicum F_1 hybrid 'Swarna' (Syngenta India Ltd., Hyderabad, India) were transplanted. Locally available dried grasses and crop residues were used as mulch. There was significant effect of irrigation level and mulching on plant height, fruit length, fruit weight, number of fruits per plant, yield potential and post-harvest life of fruits (Table 6). The T-2 treatment yielded maximum productivity which is at par with T-1, T-3 and T-4. Water requirement after plant establishment could be reduced by 25-50 % by use of organic mulch in capsicum.

Table 6: Effect of organic mulching and irrigation levels on growth and yield of capsicum

Treatment	Plant height (cm)	Fruit length (cm)	Fruit weight (g)	No. of fruit/ plant	Fruit yield (g/ plant)	Yield (q/ ha)	Post-harvest life (day)
T-1	57.3	6.3	64.6	8.3	533	200	7.8
T-2	57.3	6.4	67.7	8.4	569	213	9.6
T-3	56.7	6.4	67.5	8.4	565	212	10.2
T-4	52.6	5.2	66.8	7.8	523	196	11.2
T-5	50.4	4.7	62.5	6.5	407	153	8.4
Avg	54.9	5.8	65.8	7.9	519	195	9.4
LSD at 5%	5.7	0.7	2.9	1.1	68	26	1.7

Cherry pepper (Annual Report Barapani 2010):

The mulching materials of black polythene, transparent polythene, forest leaf and *Schima wallichi* leaf were used. Mulching in cherry pepper with *Schima wallichi* recorded minimum wilting (11%) followed by forest leaf mulch and black polythene in cherry pepper and maximum in control (75%).

Ginger (Annual Report Barapani 2010):

The dried biomass of a weed (*Ambrosia spp*.) as mulch influenced rhizome yield most prominently and along with 100% recommended NPK. The rhizome yield was increased by 183% over absolute control.

Khasi mandarin (Annual Report Barapani 2010):

An experiment on mulching viz. black polythene, pine tree leaves, farm grass, leaves of ricebean, *Flemingia macrophylla*, *Crotolaria tetragona* and *Tephrosia candida* along with control (without mulch) was executed on four years old Khasi mandarin to estimate the effects of various mulches on plant growth and weed population in Khasi mandarin. The leaves and grass were applied @ 2 kg/ m^2 twice in a year, i.e. July and November. Maximum plant height (2.53 m) and canopy spread (88.75 cm) was recorded in *C. tetragona* mulch, while stem diameter (6.07 cm) and no. of branch/ plant (30) in *T. candida* leaves and ricebean mulch, respectively. Minimum weed density was found under black polythene mulch (0.15 kg/ m^2) followed by pine leaves (1.07 kg/ m^2) and maximum in control (1.97 kg/ m^2).

Mulching in strawberry (Annual Report Barapani 2010):

Field study with different mulches, viz. transparent polythene mulch (TPM), BPM, grass mulch, pine needle mulch and no mulch were tried along with four different organic manures (pig manure, poultry manure, FYM and vermicompost). All the mulches maintained were comparatively higher in soil moisture than un-mulched field. Higher moisture regime was noticed with the depth of 10 cm under BPM followed by TPM. Among the organic mulches, pine mulch conserved more moisture than others. BPM conserved the moisture being 34% higher than un-mulched field. Temperature of the soil was also increased in BPM followed by TPM. In the morning TPM recorded higher temperature than BPM. Among the manures vermicompost recorded the highest fruit yield followed by pig manure. Number of fruits per plant was 40.28 in BPM. The income was 1.54, 1.38, 1.29, 1.16 times higher respectively compared to control. In another experiment, mulching with *Sacharum* spp. gave 70% marketable yield followed by tree leaves and paddy straw. Plant mortality was recorded maximum under black polythene mulching followed by paddy straw.

C. **Vermicomposting**

Vermicomposting is a simple biotechnological process of composting (bio-oxidation and stabilization of organic materials involving the joint action of earthworms and micro-organisms), in which certain species of earthworms, especially *Eisenia foetida*, are used to enhance the process of waste conversion and produce a better end product. It is a mesophilic process, utilizing microorganisms and earthworms that are active at 10–32°C. The process is faster than composting; because the material passes through the earthworm gut, a significant but not yet fully understood transformation takes place, whereby the resulting earthworm castings (worm manure or vermicompost) are rich in microbial activity and plant growth regulators. In most parts of North East regions of India, forest and crop-plant residues are readily available in plenty which could be utilized to generate nutrient rich bio-fertilizer (vermicompost) by vermicomposting technology for sustainable production and land fertility restoration (Brajendra et al. 2006). Further, species of earthworm that can consume and degrade a wide range of organic residues such as crop/ plant residues, animal wastes, forest residues, sewage, sludge and industrial refuses are known. The biologically decomposable organic wastes commonly used as composting materials are 15 days old animal dung; and various agricultural and Farm waste in 4: 1 ratio. There is accumulating scientific evidence that vermicompost has a significant positive influence on the growth, productivity, shelf-life and quality of crop plants; improves the physical, chemical and biological properties of soil; and provides all type of plant nutrients in available form (Peyvast et al. 2008, Premsekhar and Rajashree 2009, Singh et al. 2010a, Singh et al. 2011e and Singh et al. 2013b).

How to use vermicompost in horticultural crops?

- Vermicompost can be used for all crops: Agricultural, vegetables, fruits, plantation, ornamentals and nursery growth medium.

- For potting mixture and nursery bed: Use of vermicompost in potting mixture and nursery bed (vermicompost and soil in 1:1 ratio) results in higher and quick seed germination, higher percentage of primary roots, healthy and vigorous seedlings, and better anchorage to the plants.
- For carrier medium: Vermicompost is being used as carrier medium with various bio-fertilizers like *Azospirillum*, *Azotobacter*, Phosphate solublizing bacteria (PSB), *Rhizobium*, etc. @ 100 kg/ ha to facilitate well distribution and better growth medium of bio-fertilizers.
- For fruit trees: The amount of vermicompost ranges from 10-30 kg/ tree depending on the age and nature of the plant. For efficient application, a ring (15–20 cm deep) is made around the plant followed by water spraying/ sprinkling on the surface.
- For vegetables: Vermicompost around 5-7 t/ ha or 300–400 g/ transplant is applied initially at the time of sowing/ transplanting.
- For flowers: Vermicompost is applied @ 1-2 t/ ha.

Unlike chemical fertilizers which are applied at certain growth stages of crops, vermicompost can be applied at any stage of crop growth. As compared to single dose, split doses have been found to give better results. Beneficial residual effects of vermicompost application have also been observed in subsequent crops.

D. Use of high yielding varieties/ genotypes and better crop management

The high yielding varieties/ genotypes play a vital role in the progress of horticulture as well as agriculture. It increases the productivity, production, and thereby profitability and livelihood. Therefore, it is indispensable to use the quality seeds of high yielding varieties. We would like to enlist here some of the varieties/ genotypes of horticultural crops (Table 7) which performed excellently at ICAR-RC-NEH Region, Mizoram Centre, Kolasib, Mizoram (Singh et al. 2010b, 2011a, 2011b, 2011c, 2011d and 2013b).

Table 7: List of high yielding varieties (ICAR Kolasib)

Horticultural crop	**High yielding variety/ hybrid/ genotype**
Tomato	Avinash-2, Arvind, NIZ-124, Rita, GS-600, SO-16, Crystal-440, NP-169, TO-1458, TO-017, Pusa Divya, Pusa Ruby, Pusa Gaurav, Pusa Rohini, Sioux, Arka Abha, Arka Saurabh, Arka Alok, Sel-1, Sel-2, Sel-3, Pusa 120 and Punjab Chhuhara
Cabbage	KGMR-1, Golden Acre, Ryozeki, Pragati Plus, Pusa Mukta, Quisto, Blue Diamond, Pride of India
Broccoli	Harumi-188, Pushpa, Aishwarya, Fiesta, Pusa KTS-1, Lucky
Cauliflower	Ashmita, Shobha, Pusa Snowball, Poosi, Pusa Subhra, Pusa Snowball K-1, Pusa Himjyoti and Meghalaya Local
Carrot	Nantes, Pusa Meghali, Pusa Yamdagini, Pusa Kesar, Meghalaya Local
Brinjal	Pusa Hybrid-5, Pusa Hybrid-6, Navkiran, Pusa Purple Long, Pusa Purple Cluster, KT-4, Pant Samrat, Pant Rituraj, Pusa Bhairav, Arka Kushumakar, Arka Sheel, Arka Shirish, Pusa Kranti, Megha Brinjal-1, Megha Brinjal-2 and Megha Brinjal-3
Turmeric	RCT-1 (Megha Turmeric-1), Lakadong, IISR Allepy Supreme, IISR Pratibha, IISR Kedaram, Roma, Rasmi, Suranjana, Duggirala, Mizoram Local (IC-588797)
French bean	Arka Komal, Kentucky Wonder, Sel-35 (Meghalaya), Sel-37 (Meghalaya), Sel-19 (Manipur), Mizoram Locals (MZFB-27, MZFB-30, MZFB-40, MZFB-48, MZFB-44, MZFB-45, MZFB-47)
Knol-khol	Winner, Early Vienna, Late Vienna, White Vienna
Okra	Arka Anamika, VRO-6, Arka Abhay, Prabhani Kranti, Varsha Uphar, Pusa A-4, Pusa Makhmali, Punjab Padmini
Cowpea	Yard Long Bean, Pusa Komal, Mizoram Locals (MZCP-9, MZCP-10 and MZCP-11)
Chinese kale	Mizoram Local (IC-590588)
Vegetable mustard	Mizoram Locals (IC-590585, IC-590586, IC-590587)
Ginger	Nadia, Thingaria, Thinglaidum, Thingpui, Basar Local and Meghalaya Local
Bird eye chilli	Mizoram Local
King chilli	Mizoram Locals (IC-590813, MZNC-2, MZNC-3)
African eggplant	Mizoram Local
Chow-chow	Mizoram Locals (Local-1, Local-2, Local-3, Local-4)
Passion fruit	Purple
Banana	Giant Cavendish, Mizoram Local
Mandarin	Khasi Mandarin

Mizoram Local: These are the local land races collected from Mizo farmers and evaluated at ICAR Kolasib, Mizoram.

E. **Crop and orchard management**

Crop and orchard management is another vast area to realize the genetic potential efficiently. The ICAR-RC-NEH Region, Mizoram centre, Kolasib, Mizoram has tested different types of technologies/ interventions in various horticultural crops which are able to increase the productivity by 10-60 %. These are as follows:

Banana

- Maintenance of 2 suckers/ plant of cv. Giant Cavendish at 3×3 m spacing and application of NPK @ 300:100:300 g/ plant are the best way to realize the yield potential.
- Again application of vermicompost @ 10 kg/ plant or pig manure @ 10 kg/ ha or poultry manure @ 5 kg/ plant increases the productivity by 10-20 % as well as quality of the fingers.

Passion fruit

- The performance of Purple cultivar, both yield and fruit quality, was found best at spacing of 3×3 m and application of NPK @ 50:125:60 g/ plant + vermicompost @ 4-5 kg/ plant + poultry manure @ 5 kg/ plant.
- Application of bio-fertilizer 10 ml each of *Azospirillum* + PSB or *Azotobacter* + PSB enhances the juice quality and fruit yield by 15-20 %.
- There is minimum loss in fruit weight by storing the fruits in plastic boxes and low density polythene.

Mandarin orange

- Citrus rejuvenation by organic mulching (October-March), liming, Bordeaux pasting on trunk, application of NPK @ 400: 200:400 g/ plant along with vermicompost @ 12 kg/ plant or FYM @ 20 kg/ plant or poultry manure @ 10 kg/ plant improves the productivity by 15-30 %.
- Spray of micronutrients ($ZnSO_4$ @ 0.5 % + $CuSO_4$ @ 0.4 % + $MnSO_4$ @ 0.4 %) has given significantly higher yield and improves physico-chemical attributes of fruits.

- Spray of plant growth regulators (NAA @ 20 ppm + GA3 @ 10 ppm) thrice at vegetative growth, flowering and fruit setting stage improves the plant growth, yield (15-20 %) and juice quality.

Pineapple

- Double row planting system (0.4×0.6×0.9 m) of pineapple cv. Kew gave early flowering and 10-20 % more yield than other planting systems.

Chow-chow

- Application of lime @ 500 g + FYM @ 8 kg + NPK @ 250:150:300 g + *Trichoderma* @ 25 g + PSB @ 25-50 g + vermicompost @ 10 kg or pig manure @ 5-10 kg per basin increased the yield by 15-20 %. Furthermore, removal of dried and old leaves especially in old crops improves the translocation of photosynthates from source to sink and thereby increasing the yield by 10-12 % (Singh et al. 2012).

Tomato

- Ten hybrids were found to be potential for better yield (q/ ha) with highest for Arvind (538) followed by NIZ-124 (534), Rita (506), GS-600 (467), SO-16 (464), Crystal-440 (463), Avinash-2 (450), NP-169 (443), TO-1458 (424) and TO-017 (420). The uniformity in fruit shape, attractive colour, uniform ripening and calyx persistency are excellent for Avinnash-2, Crystal-440 and SO-16 as these traits will attract more consumers.
- Application of fertilizer NPK @ 25-50:15-30:15-30 kg/ ha along with vermicompost @ 7.5-10 t/ ha were found to enhance the growth of plants, yield potential and quality of fruits. The TSS and post-harvest life of fruits are almost increasing with increase in vermicompost quantity. Post-harvest life of fruits was increased by 90-250 % with the application of vermicompost as compare to fertilizer alone.

French bean

- Ten genotypes, all collected from Mizoram, showed better pod yield potential (>135 q/ ha) which is maximum in MZFB-27 (184 q/ ha) followed by MZFB-30 (176 q/ ha), MZFB-40 (161 q/ ha), MZFB-48 (156 q/ ha), MZFB-44 (148 q/ ha), MZFB-32 (145 q/ ha), MZFB-38 (143 q/ ha), MZFB-29 (141 q/ ha), MZFB-51 (138 q/ ha) and MZFB-47 (137 q/ ha).
- Two unique lines (MZFB-44 and MZFB-48) with purple-pod contain higher anthocyanin content (15-16-fold) identified (Singh et al. 2011d).

Cauliflower

- The variety Asmita performed well with the productivity of 298 q/ ha followed by Poosi (284 q/ ha), Pusa Snowball (275 q/ ha) and Deepa (224 q/ ha). The variety Deepa showed early maturity for 15 days than other varieties.
- The basal application of borax @ 20 kg/ ha and ammonium molybdate @ 2 kg/ ha would enhanced the plant growth, curd yield and quality.

Cabbage

- The productivity of KGMR-1 (410 q/ ha) was highest followed by Blue Diamond (326 q/ ha), Harnil (305 q/ ha), Golden Acre (291 q/ ha), Bahar (281 q/ ha), Quisto (267 q/ ha), No.-139 (255 q/ ha), Pusa Mukta (254 q/ ha) and Fieldman (246 q/ ha).
- The yield of cultivars transplanted on 1st December was found to be best followed by transplanting on 13th November and 18th December in general. KGMR-1 (bred by IARI Regional Station, Katrain, HP) showed better heading at higher temperature during February-March in Mizoram conditions (Singh et al. 2010c).
- The application of vermicompost @ 7.5-10 t/ ha along with fertilizer NPK @ 25-50:15-30:15-30 kg/ ha gave highest yield and better quality of head.
- The basal application of borax @ 20 kg/ ha and ammonium molybdate @ 2 kg/ ha would enhanced the plant growth, head weight and yield.

Broccoli

- The productivity of cultivar Harumi (200 q/ ha) was highest followed by Aishwaraya (180 q/ ha), Fiesta (170 q/ ha), Premier (165 q/ ha), Lucky (160 q/ ha), Pushpa (150 q/ ha) and Pusa KTS-1 (150 q/ ha).
- The basal application of borax @ 20 kg/ ha and ammonium molybdate @ 1 kg/ ha essential for plant growth, yield and shelf-life of broccoli.

Naga chilli

- The cultivation of Naga chilli in net-house under 50 % shade increased green fruit weight by 42 %, number of fruits/ plant by 12-folds and fruit yield by 15-fold as compare to open conditions.

Brinjal

- The ratooning of brinjal hybrid 'Navkiran' during 3rd week of April improves the fruit size, fruit number per plant and fruit yield by 30 % as comparison to non-ratooned brinjal crop.

Carrot

- Root yield was found to be higher in Pusa Yamdagini (270 q/ ha) followed by Pusa Meghali (210 q/ ha) and Nantes (190 q/ ha) sown during 2nd week of November.
- The application of fertilizers NPK @ 40-50:15-20:20, vermicompost @ 2.5-4.0 t/ ha and mulching sustained the yield potential even with application of only 50 % irrigation water.
- Application of borax @ 20 kg/ ha enhanced the root yield of carrot by 30-60 %.

Ginger

- Better yield potential and wider adaptability was found in four cultivars, namely Nadia, Thinglaidum, Thingaria and Thingpui.

Turmeric

- The cultivars such as Megha Turmeric-1, IISR Allepy Supreme, IISR Pratibha and Suranjana showed better yield potential, wider adaptability, higher dry matter recovery and higher curcumin content. Moreover, Megha Turmeric-1 has higher curcumin content (6-7 %) as compare to other varieties (4.0-5.5 %).
- Three genotypes, namely Narendra Haldi-1, BSR-2 and Rajendra Sonia found susceptible to leaf blotch (*Taphrina maculans*) and leaf spot (*Colletotrichum curcumae* and *C. capsici*) whose incidence was maximum during 1st fortnight of October.

F. **High-tech horticulture**

High-tech horticulture is based on the modern technologies which is less dependent on environment, capital intensive, and has the capacity to improve the productivity and quality of horticultural crops. It is need of hour to adopt efficient technologies to ensure the food and nutritional security of ever increasing population and shrinking of land and water resources, and to cope up with erratic and extreme type of weather events in impending climate scenario. This includes micro-propagation, micro-irrigation, fertigation, protected cultivation (greenhouse/ poly-house, plastic mulching, low tunnel, etc.), mechanization, nutrition modeling, and use of remote sensing. Zopar Export Ltd, Bengaluru, with the support of Mizoram Government, started production and export of flowers such as rose, anthurium, chrysanthemum, gerbera, lilium, limonium and orchid, and strawberry from 2006. The firm has its own large production center at Vaipuanpho, Aizawl. Zopar is providing technological know-how in big-way to the state floriculture department's own flower farm at Champai as well as the progressive farmers of Aizawl and Champhai districts, and also marketing their produce to the National and International markets. More than 1,000 families are engaged in cultivation of the flowers in Mizoram, out of which 275 were Hi-tech producers. Entrepreneurship development through cultivation of flowers has not only brought about a change in the Horticulture scenarios of Mizoram, but also uplifts the

living condition of the growers to a great extent. It is a successful model of Public-Private-Partnership (PPP) in which the roles of Mizoram Government, Zopar and growers are synergized very efficiently (Singh et al. 2013b). The model of success is also being replicated for vegetable cultivation and production of quality planting materials in protected structures.

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