Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

June 2023, Volume 36, Issue 1, Page 85-93

Participatory intervention in farmer's practice of vegetable production to increase productivity in hill agriculture

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ARTICLE INFO

Article history:
Received: 15 December, 2022
Revision: 28 December, 2022
Accepted: 10 January, 2023

Key words: *Vegetables, Hills, Participatory, Farmers, Productivity*

DOI: 10.56678/iahf-2023.36.01.12

ABSTRACT

Blending of improve practices with farmer's practice of cultivation of vegetable crops for enhancing sub-optimal productivity was undertaken in a participatory approach in farmer's field covering villages *viz.*, Mawmih, Mawlaiteng, Lawmei and surrounding of East Khasi Hills District, Meghalaya. Treatments comprised of mulching with weed biomass, organic manure and combined application of mulching and organic manure, were imposed to find out if there is any improvement on crop productivity as compared to farmer's practices. Results indicated that adoption of such feasible improved intervention increased the productivity by 25.38-25.53 % (cabbage), 33.44-37.85 % (cauliflower), 14.43-16.00 % (French Bean), 6.32-9.81 % (Pea), 13.91-16.03 % (radish) and 30.41-36.22 % (Carrot) as compared to farmer's practice in these difficult terrains of Meghalaya.

1. Introduction

Vegetables have plethora of uses for human nutrition and health security since they are the sources of dietary fiber, phytochemicals, vitamins and minerals (Wargovich, 2000; Liua *et al.,* 2001). Besides, cultivation of vegetable crops is highly remunerative with higher employment opportunities and income per unit area than other agricultural crops. India is the second largest producers of vegetables in the world (132.03 million tonnes), only next to China (588.26 million tonnes), the productivity of vegetables is however, very low (17.97 tha^{-1}) in the country over China (>28 tha^{-1}) and other central Asian countries (>23.9 tha^{-1}) (Anon., 2019). In the Northeastern hilly states of Meghalaya, more than 77 % of the total geographical area (GA: 2.24 M ha) is hilly topography and more than 82 % GA is under forest cover. As a result, area under cultivation of agricultural and horticultural crops is meager (<6.0 % GA). Of the total GA of the state, vegetables are cultivated only in 2.19 % area (0.049 Mha) with a total production of only 0.519 million tonnes and a productivity of 10.5 t ha^{-1}, almost half the national average productivity of the country (Anon., 2019). This sub-optimal productivity of vegetables in the state is attributed mainly to multiple factors namely soil moisture stresses from extremely erratic rainfall distribution in spatio-temporal dimensions, soil acidity induced fertility stress and poor soil health management, marginal–input intensive cultivation practices and use of poor low-yielding planting/seed materials (Verma *et al.*, 2020). Sharma *et al.* (2019) pointed out that vegetable crops require balanced and sufficient supply of nutrients and moisture for better growth and higher yield. Since in Meghalaya, use of inorganic fertilizers are restricted, therefore, organic nutrition from the locally available cheap sources like FYM, composts, poultry and pig manures will substantially help to get optimum productivity while maintaining soil health sustainability in the long run. Weed biomasses (in-situ) as mulching with organic sources also improves the soil physical health (water retention and transmission *vs.* evaporation losses), supplying plant nutrients on decomposition, improving soil biological activities through beneficial microbes and enzymes and thus, have the potential to increase the yield while helping in overcoming severe form of abiotic stresses (Bhardwaj, 2013). Different researchers have recorded the highest marketable yield of cabbage (Sarker *et al.*, 2003), cauliflower (Singh and Singh, 2019), carrot (Mazed *et al.* 2015), radish (Zeid *et al.*, 2015), pea

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(Devi *et al.*, 2018) and french bean (Rana *et al.*, 1998) with organic manure and mulching. Keeping this in view, we made an attempt in farmer's participatory approach to incorporate affordable (to tribal farmers) intervention in farmers' practice of cultivation of major vegetable crops with an objective of improvement on crop productivity.

2. Materials and Methods

2.1 Study Site

The experiment was conducted in the three major vegetable growing villages of East Khasi Hills district of the State of Meghalaya, lies between 25°07" & 25°41" N Latitude and 91°21" & 92°09" E Longitude and located at an elevation range of 1600 to 1700 meter above mean sea level. The climate of the study area falls under warm per humid Agro-eco Sub Region and have a temperate climate Temperature varies from 4 ^{o}C in winter to 28 ^{o}C in summer and average annual rainfall varies from 2400 to 2600 mm, of which about 65 to 69 % of the rainfall is received during monsoon months (June to October) every year. The soil of the study are are light to heavy in texture, strong to moderate in soil reaction, high in organic carbon content but low to medium in available nitrogen, phosphorus and potash contents.

2.2. Soil sampling, analysis and spatial variability mapping in GIS

After selection of the farmers and crops, we performed random composite geo-referenced soil sampling (0-20 cm depth using GPS) across 20 selected farmers field and characterized the initial soil properties including acidity and fertility parameters following standard procedures. The soil pH was determined in a 1:2.5 soil:water suspension (Jackson 1973), soil organic carbon (SOC) by Walkley and Black method (1934), available N by alkaline potassium permanganate method (Subbiah and Asija 1956), available P_2O_5 by Bray's method (Bray and Kurtz 1945) and available K_2O by Ammonium Acetate Extraction method (Jackson 1973). The study area was demarcated, digital boundary was prepared in ArcGIS (v.2010.v2) (Fig.1) and with the help of Community and Rural Development Block (Mylliem and Mawphlang), the boundary and area under each of the three villages were verified. Then land-use land cover (LULC) map of the study area was generated from multi-date IKNOS satellite data (Fig. 2).

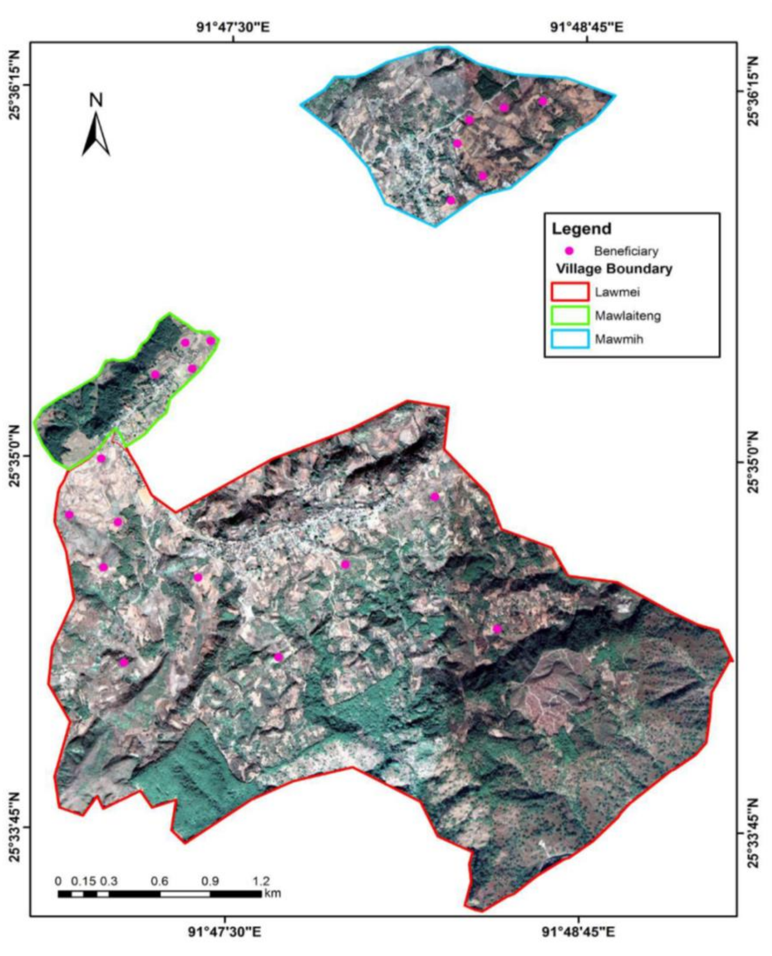

Figure 1. Boundary map of the study area.

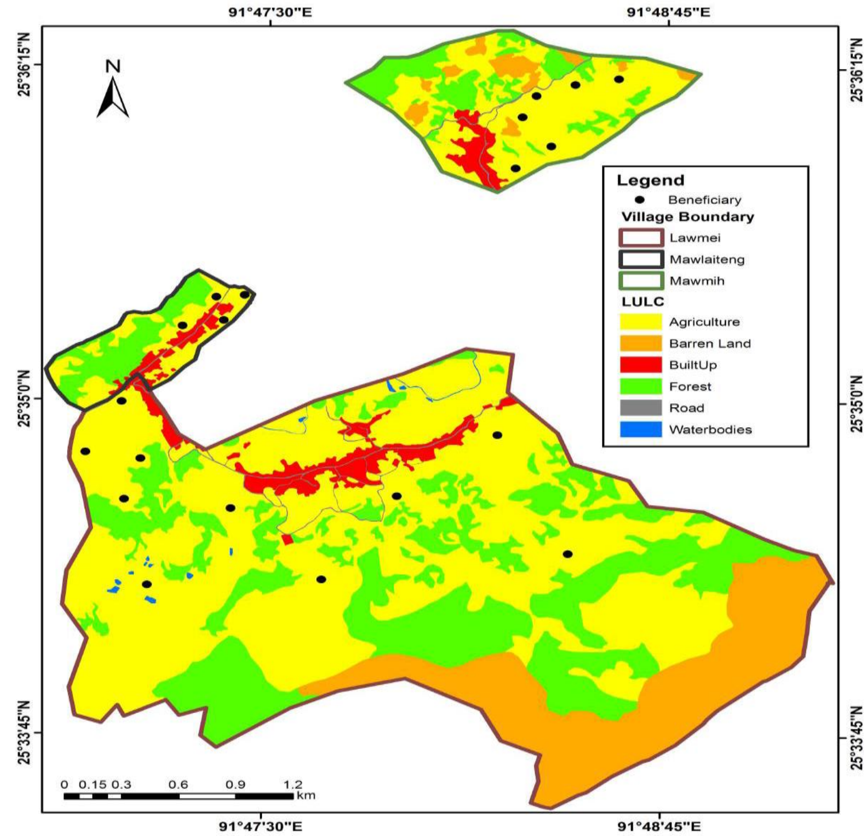

Figure 2. Land-use land cover (LULC) map of the study area.

2.3 Treatments

Treatments viz., T1: Farmer's practices as control (traditional practices without fertilizer and mulching), T2: Organic manure (well rotten FYM @ 5 tha^{-1}), T3: Mulching (*In-situ* fresh mixed weed biomass @ 5 tha^{-1} fresh weight) and T4: integration of T2 and T3 (FYM plus weed biomass) in triplicate for all the six crops were imposed following randomized block design (RBD). In T1, farmers grew the vegetables absolutely following their traditional way of cultivation practices (use their own seeds without manuring and mulching). In T2, the recommended dose of FYM (@ 5 tha^{-1}) was applied 20 days prior to sowing/ transplanting; in T3, weed biomasses @ 5 tha^{-1} were applied post germination/transplanting in each plot while in T4 – both T2 and T3 managements were followed. The crops reached the harvesting stage during the month of December onwards and finally, all crops were harvest by mid-February. Since most of the crops were harvested periodically (head of cabbage, curd of cauliflowers, multiple time plucking of pods in french bean, pea, roots of carrot and radish), harvesting periods extended. We measured cumulative yields (from multiple time harvesting) of each crop from all plots by standard balance (Metis Electronic Iron Weighing Scale, capacity 15 kg) and then converted them to express in tonnes per hectare basis.

2.4 Data analysis

Data were analyzed statistically using Analysis of Variance (ANOVA). The difference between the treatment means was tested for statistical significance with appropriate critical difference (C.D.) value at 5 % level of probability and the Duncan's multiple range test was used to test the significance of variance between means at p value <0.05 using PROC GLM SAS (SAS Institute, version 9.2). Significant differences were graphically represented by constructing Diffograms using PROC GLM SAS (SAS Institute, version 9.2) (SAS Institute 2010).

3. Results and Discussion

3.1 Soil chemical properties

Result revealed that soil in the study areas are healthy with a high content of organic carbon, low to high in major and micronutrients (Table 1). Soil pH ranged from 4.20 to 5.46, indicates that soil is highly acidic (pH 4.5-5.0) to moderately acidic (pH 5.0-5.5) and 65 % of the sites categorized as highly acidic. The high rainfall and leaching of some of the bases from the exchange complex resulted in acidic soils (Singh *et al.* 2016). In the study area, invariably a high SOC (> 0.75 %) recorded with a range of 1.26-2.76 % with corresponding Soil Organic Matter (SOM) content of 2.16 to 4.75 %. A high Soil Organic Carbon (SOC) improves

Table 1. Soil fertility status of the study area

Sl. No.	Sample No.	Village name	Soil pH	SOC (%)	Available nutrients (kg ha^{-1})			Available nutrients (ppm)					Ca+Mg (meq./100 g soil)
					N	P_2O_5	K_2O	S	Fe	Mn	Zn	Cu	
1.	Sample 1	Mawmih	5.18	1.59	326.14	43.49	642.54	6.53	45.04	3.19	0.58	0.69	3.30
2.	Sample 2	Mawmih	4.62	1.56	326.14	83.63	208.66	10.26	34.13	3.16	0.76	0.61	1.20
3.	Sample 3	Mawmih	5.20	2.34	388.86	57.49	424.82	3.43	47.02	1.29	0.59	0.71	2.50
4.	Sample 4	Mawmih	4.81	2.61	464.13	57.49	234.30	2.03	66.52	4.40	1.47	1.38	2.30
5.	Sample 5	Mawmih	5.80	1.71	326.14	61.22	127.76	13.69	54.48	4.25	1.70	0.86	4.30
6.	Sample 6	Mawmih	5.01	2.70	413.95	96.69	464.69	1.82	81.42	2.54	1.17	0.80	2.30
7.	Sample 7	Mawlaiteng	4.87	2.43	476.67	88.29	409.14	2.04	61.92	7.02	1.22	0.96	1.50
8.	Sample 8	Mawlaiteng	4.78	1.65	313.60	27.63	267.57	1.44	38.34	1.55	0.70	1.06	1.10
9.	Sample 9	Mawlaiteng	4.56	2.49	514.30	35.09	147.84	2.96	29.02	2.95	0.46	1.18	1.00
10.	Sample 10	Mawlaiteng	5.39	2.13	326.14	36.03	330.40	179	27.24	2.77	0.40	1.06	1.90
11.	Sample 11	Lawmei	4.30	1.65	451.58	97.63	155.57	50.61	33.62	10.47	1.01	0.92	1.70
12.	Sample 12	Lawmei	5.46	2.31	351.23	74.29	267.86	222.93	65.17	23.55	4.67	2.06	13.70
13.	Sample 13	Lawmei	4.69	2.25	426.50	89.23	327.04	10.55	37.53	2.53	1.01	0.80	1.80
14.	Sample 14	Lawmei	4.74	1.71	263.42	43.49	136.86	4.71	41.27	11.25	0.33	1.14	1.40
15.	Sample 15	Lawmei	4.68	2.34	388.86	65.89	180.77	5.29	32.53	2.49	0.92	0.77	1.50
16.	Sample 16	Lawmei	4.26	1.53	288.51	51.89	125.10	29.68	29.53	2.65	0.31	0.78	1.60
17.	Sample 17	Lawmei	5.07	1.71	351.23	94.83	145.04	2.23	78.94	3.78	6.64	1.36	3.30
18.	Sample 18	Lawmei	4.49	1.98	326.14	61.23	133.39	10.09	41.64	3.38	0.71	1.36	1.80
19.	Sample 19	Lawmei	4.20	1.26	313.60	48.16	193.31	7.86	25.01	2.53	0.20	0.79	1.90
20.	Sample 20	Lawmei	4.66	2.76	413.95	54.69	394.24	6.98	53.07	5.07	0.74	1.07	1.30

soil structural stability by promoting aggregate formation, ensure sufficient aeration and water infiltration to support plant growth (FAO, 2017).

Generally, soils in the study area recorded medium in available nitrogen and phosphorus with high content of available potassium. The available major nutrients ranged from 263.42- 514.3 kg ha^{-1} available nitrogen, 27.63-97.63 kg ha^{-1} available phosphorus and 125.1-642.54 kg ha^{-1} in available potassium. Similarly soils in the study area registered low in secondary (Ca, Mg and S) nutrients and zinc (0.2-6.64 ppm) with high content of available iron (25.01-81.42 ppm), manganese (1.29-23.55 ppm) and copper (0.61-2.06 ppm). Similarly, many authors reported a low content (0.4 to 8.0 ppm) of Zn (Singh *et al.*, 2012) and high content of Fe, Mn and Cu (Venkatesh *et al.*, 2003) in acid soils of Meghalaya.

3.2 Yield attributes of vegetable crops

3.2.1. Cabbage:

Table 2 clearly indicates that yield attributes of cabbages was significantly maximum by mulching with weed biomass @ 5t ha^{-1} + FYM @ 5tha^{-1} (40.17 t ha^{-1}) which was 25.53 % higher than farmer's practices (32.00 t ha^{-1}). When mulching with weed biomass @5 t ha^{-1} was applied, the increased in yield (40.12 t ha^{-1}) was 25.38 % than farmer's practice, while on application of farmyard manure @ 5t ha^{-1}, yield (38.90 t ha^{-1}) increased by 21.56 %. The increased in yield of cabbage was contributed by the improvement in size of individual head as evidenced that mulching + weed biomass @ 5 t ha^{-1} + FYM @ 5 t ha^{-1}produced highest weight (1.36 kg) which was 33.33 % higher than farmer's practices (1.02 kg). This finding is in accordance with Sarker *et al.* (2003) who obtained 179.04 % more yield in cabbage with combined application of organic manure and water hyacinth mulch than control.

3.2.2. Cauliflower: Yield of cauliflower was significantly higher under mulching with weed biomass @ 5 t ha^{-1} + FYM @ 5 t ha^{-1} (35.29 t ha^{-1}) which was 37.85 % more than farmer's practice followed by mulching with weed biomass @ 5 t ha^{-1} (33.44 %, Table 3). The increased in yield was mainly contributed by the improvement in weight of curd. Weight of cauliflower curd (1.08 kg) was maximum in combined application of mulching with weed biomass @ 5 t ha^{-1} and farmyard manure @ 5 t ha^{-1}, increased by 54.29 % over farmer's practice (0.70 kg) followed by mulching with weed biomass @ 5 t ha^{-1} (41.43 %) and FYM alone @ 5 t ha^{-1} (35.71 %). Farzana *et al.* (2016) obtained higher yield of cauliflower by organic manure application over control. Similarly, Singh and Singh (2019) obtained higher yield in cauliflower with bio-fertilizer + paddy straw mulching as compared to control. Salim *et al.* (2008) conducted an experiment on cauliflower with the treatments comprising with or without polyethylene mulch and the three varieties of Poushali, Snow crown and IPSA-1 and they have found that there was a positive effect of mulch on yield and yield attributes of cauliflower. They have also found that highest marketable yield (31.32 t ha^{-1}) was obtained from hybrid variety Snow Crown with mulch was 35.16 % higher than without mulch and the other two varieties also produced higher yield under mulched condition than without mulch condition. Kumar *et al.*, (2019) reported that mulching along with the different levels of NPK nutrients improved the growth parameters and also increase the productivity and uptake of secondary nutrients of cauliflower. They also found that black plastic mulch in combination with 125 % of recommended dose of NPK obtained the highest curd yield (26.7 t ha^{-1}). Akhter *et al.* (2016) reported that highest yield (38.70 t/ha) in cauliflower was obtained with the application of organic manure in the form of mustard oil cake at the rate of 3.5t/ha. and the lowest yield (19.71 t ha^{-1}) obtained in the control treatment. Devkota *et al.* (2021) reported that the half dose of organic manure (750 kg ha^{-1}) and half dose of farm yard manure (20 t ha^{-1}) gives highest curd yield (1019 g) and biomass (2046 g) in cauliflower. They have also found that highest nitrogen percent (0.10 %), organic matter percent (1.89 %) and phosphorus content (169.09 mg/kg) were obtained with the application of combined half dose of NPK (105:90:60 NPK kg ha^{-1}) and half FYM (20 t ha^{-1}). At last they have concluded that the combined effect of application of organic manures with inorganic fertilizers (NPK) was found to be better for crop growth and development as well as soil health improvement.

Table 2. Effect of treatments on cabbage weight and yield

Treatment	Yield (t ha^{-1})		Head weight (kg)	
	Range	Mean + SD	Range	Mean + SD
T1: Farmer's practice	30.10-34.02	32.00 + 1.14c	0.85-1.23	1.012 + 0.11c
T2: Mulching	37.56-41.81	40.12 + 1.15a	1.24-1.51	1.33 + 0.08a
T3: Organic manure	37.02-41.66	38.90 + 1.38b	1.17-1.44	1.27 + 0.08b
T4: Mulching + Organic manure	37.61-41.86	40.17 + 1.55a	1.05-1.48	1.36 + 0.11a
LSD (p=0.05)	-	0.79	-	0.05

Table 3. Effect of treatments on cauliflower weight and yield

Treatment	Yield ($t ha^{-1}$)		Curd weight (kg)	
	Range	Mean + SD	Range	Mean + SD
T1: Farmer's practice	21.46-29.82	25.60 + 2.34d	0.52-0.9	0.70 + 0.10d
T2: Mulching	29.86-38.22	34.16 + 2.39b	0.85-1.15	0.99 + 0.08b
T3: Organic manure	29.50-37.89	33.53 + 2.59c	0.80-1.10	0.95 + 0.08c
T4: Mulching + Organic manure	30.98-39.34	35.29 + 2.39a	0.93-1.23	1.08 + 0.08a
LSD (p=0.05)	-	0.42	-	0.02

3.2.3. French Bean: Different improved management practices do not significantly influence the yield of french bean. However fig. 3 indicated that mulching with weed biomass @ 5 t ha^{-1} coupled with farmyard manure application @ 5 t ha^{-1} could increase the yield of french bean (12.54 t ha^{-1}) by 16 % followed by farmyard manure @ 5 t ha^{-1} (15.91 %) and mulching with weed biomass @ 5 t ha^{-1} (14.43 %) over farmer's practice (10.81 t ha^{-1}). Similar result was obtained by Sarma *et al.*, (2014) in french bean where yield was higher by 42-100 % with organic manure as compared to control. Further Kwambe *et al.*, (2015) obtained better yield of french bean with mulching as compared to non-mulching. Kamal *et al.*, (2010) reported that the french bean yield was increased due to the use of mulching. Use of black polythene mulch gave highest yield (15.01 t ha^{-1}) and the lowest yield was obtained from the control treatment (12.73 t ha^{-1}). They have also reported that the benefit cost ratio (BCR) was maximum (1.98) in the treatment of black polythene mulch and the lowest BCR (1.74) was in control treatment. Ramesh *et al.*, (2021) reported that mulching with polythene and 100 per cent RDF through fertigation in french bean gives highest plant height (51.55 cm), number of primary branches (6.64), leaf area (564.54 cm^2), leaf area index (1.06), number of pods per cluster (10.02), number of clusters per plant (7.41), yield per plant (80.94 g), yield per hectare (11.58 t ha^{-1}), nitrogen uptake (92.30 kg ha^{-1}), phosphorous uptake (9.25 kg ha^{-1}), potassium uptake (80.91 kg ha^{-1}), nitrogen use efficiency (178.35 kg pods per kg of nitrogen), phosphorous use efficiency (106.30 kg pods per kg of phosphorous), potassium use efficiency (144.12 kg pods per kg of potassium), and water use efficiency (504.02 kg ha^{-1} cm^{-1}). They also reported that higher shelf life (8.05 %), higher moisture content (89.05 %), higher firmness (4.05 $kgcm^{-2}$) and higher crude fibre content (16.19 %) in the pods were recorded where mulching was applied along with 100 per cent RDF through fertigation as compared to the other treatments.

3.2.4. Pea: Different treatments significantly influenced the yield of pea (fig. 3). Combined application of mulching with weed biomass @ 5 t ha^{-1} along with farmyard manure @ 5 t ha^{-1} improved the yield of pea (8.17 t ha^{-1}) by 9.81 % followed by 8.20 % in farmyard manure @ 5 t ha^{-1} and 6.32 % in mulching with weed biomass @ 5 t ha^{-1} over farmer's practice. This result corroborated the finding of Gopinath and Mina (2013) who obtained higher yield of pea by organic manure application as compared to control. Similarly Sajid *et al.* (2013) obtained more yield in pea by organic mulching in comparison to control. Awal *et al.* (2016) reported that plant height, number of primary branches per plant, leaf area index, dry matter accumulation, seed yield and yield contributing characters like number of pod per plant and seed per pod, seed weight per plant and individual seed weight were influenced by different mulches in pea. Highest yield characters observed when crops grown with black or transparent polyethylene mulches whereas lowest yield observed when crop grown with rice straw mulch or control. They have also found that highest seed yield was observed from the crops grown with black (5.66 t ha^{-1}) or transparent polyethylene covers (5.54 t ha^{-1}), and the lowest occurred with rice straw (4.38 t ha^{-1}) or with no mulch (4.26 t ha^{-1}).

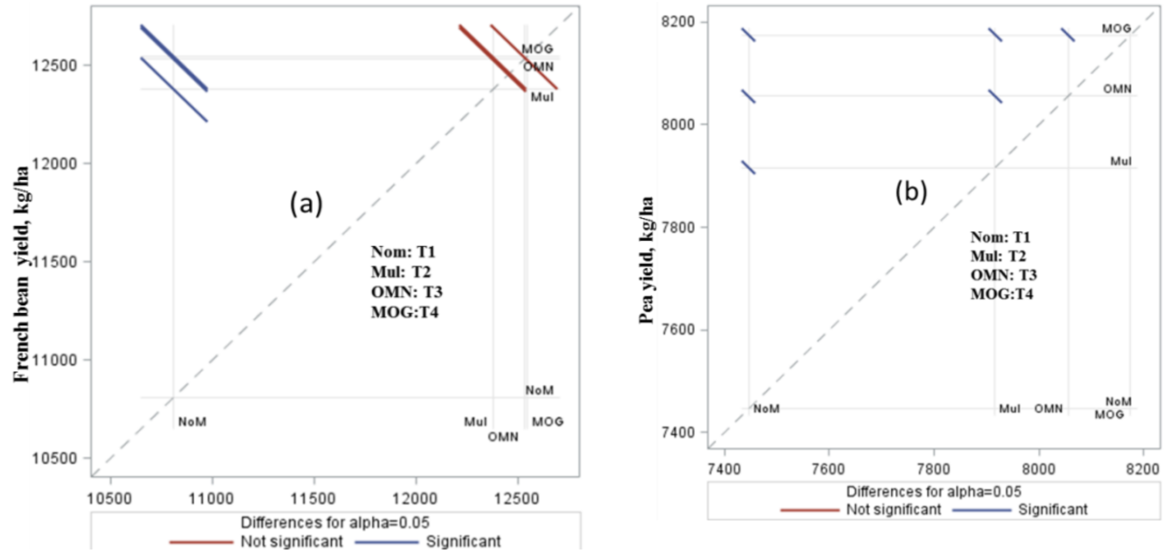

Figure 3. Comparison of french bean and pea yield for treatments

3.2.5. Carrot: The fresh weight of root significantly differed with treatments (Table 4). Maximum weight (155.92 gm) was obtained in combined application of mulching with weed biomass @ 5 t ha^{-1} and farmyard manure @ 5 t ha^{-1} which was 43.81 % over farmer's practice (108.42 gm) followed by 35.25 % in mulching with weed biomass @ 5 t ha^{-1} and 34.86 % in farmyard manure application @ 5 t ha^{-1}. The improvement in size particularly weight of roots contributed much to the increased in yield of carrot. Yield increased by 30.41 % in mulching with weed biomass @ 5 t ha^{-1}, 32.40 % in farmyard manure @ 5 t ha^{-1} and 36.22 % when mulching with weed biomass @ 5 t ha^{-1} combined with farmyard manure @ 5 t ha^{-1} against farmer's practice. Similar findings were reported by Rahman *et al.* (2018) reported that mulching have a significant positive effect on the increasing root yield components and the beta-carotene contents of carrot over non-mulched treatment. They also stated that organic and inorganic sources of nutrients along with mulch effectively increased the carrot yield than crop supplied with only higher doses of manures and fertilizers. Rani *et al.* (2016) reported that farmyard manure and mulches with water hyacinth produced highest fresh weight of root (121.31 g), total yield (57.93 t ha^{-1}) and marketable yield (49.11 t ha^{-1}) the lowest 54.61 t ha^{-1} and 45.12 t ha^{-1} were from control treatment. Biswas *et al.* (2019) reported that application of organic manure resulted in maximum plant height (44.55 cm), root weight (124.50 g), root yield (24.90 t ha^{-1}) and marketable root yield (23.85 t ha^{-1}). With the use of mulches, plant height (44.81 cm), root weight (117.85 g), root yield (23.57 t ha^{-1}) and marketable root yield (21.95 t ha^{-1}) was maximum and in combined effect, the highest root yield (29.06 t ha^{-1}) was obtained as compare to 13.20 t ha^{-1} from control. At last they have concluded that 10 t ha^{-1} vermicompost with black polythene mulch was the best for carrot cultivation.

Table 4. Effect of treatments on Carrot yield and weight

Treatment	Yield (t ha^{-1})		Root weight (g)	
	Range	Mean + SD	Range	Mean + SD
T1: Farmer's practice	15.22-22.15	18.25 + 2.42c	81-141	108.42 + 19.57c
T2: Mulching	21.08-25.90	23.80 + 1.31b	118-200	146.64 + 26.83b
T3: Organic manure	22.50-27.75	24.17 + 0.91ab	111-187	146.21 + 24.27b
T4: Mulching + Organic manure	22.13-26.95	24.86 + 1.31a	130-195	155.92 + 22.40a
LSD (p=0.05)	-	0.702	-	4.10

3.2.6. Radish: Significant improvement in weight of radish was obtained in various treatments as compared to farmer's practice (Table 4). Maximum weight of root (298.69 gm) was observed in combined application of weed biomass @ 5 t ha^{-1} as mulch along with farmyard manure @ 5 t ha^{-1} followed by mulching with weed biomass alone (271.23 gm) and application of farmyard manure @ 5 t ha^{-1} which was 42.23 %, 29.16 % and 19.85 % respectively higher than farmer's practice. This improvement in root weight subsequently results in productivity enhancement where application of weed biomass @ 5 t ha^{-1} as mulch increased the yield by 13.91 %, farmyard manure @ 5 t ha^{-1} by 10.07 % while combined application of weed biomass @ 5 t ha^{-1} as mulch and farmyard manure @ 5 t ha^{-1} by 16.03 % over farmer's practice. Under Lucknow condition, Kumar *et al.* (2014) reported similar finding that application of organic manure *viz*., poultry manure (50 %) + vermicompost (50 %) was more beneficial and significantly improved growth and yield of radish var. Japanese White as compared to control.

4. Conclusion

With minimal intervention such as mulching with weed biomass, yield was increased by 25.38 % (cabbage), 33.44 % (cauliflower), 30.41 % (carrot), 13.91 % (radish), 14.43 % (french bean) and 6.32 % (pea) as compared with farmer's practice. Similarly, application of locally available sources of farmyard manure increased the yield by 21.56 % (cabbage), 30.98 % (cauliflower), 32.44 % (carrot), 10.07 % (radish), 15.91 % (french bean) and 8.20 % (pea) as compared to farmer's practice. When mulching and farmyard manure were applied together, yield increased by 25.53 % (cabbage), 37.85 % (cauliflower), 36.22 % (carrot), 16.03 % (radish), 16.00 % (french bean) and 9.81 % (pea) as compared to farmer's practice. Therefore it is recommended to apply organic manure and mulching with weed biomass to improve productivity of vegetable in sloppy upland of rainfed agriculture at affordable cost in Meghalaya particularly East Khasi Hills.

5. Acknowledgement:

Authors are thankful to the Director, ICAR Research Complex for NEH Region, Umiam for providing all the facilities and fund under Tribal Sub Plan for the successful conduct of the study.

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