Zero budget natural farming practices on yield of crops (Maize + soybean and Pea + coriander) in mid hill of Sikkim Himalayas

SK Das*a, A Kumar*a, A Yadavb, R Lahaa and VK Mishrab

Summary
Natural Farming (NF) is an alternative low-input, climate-resilient farming practice that have emerged to reduce input costs and higher yields for farmers from locally available inputs by eliminating the use of chemical fertilizers and improving soil fertility. In this article, it was physico-chemically characterized the different formulations (jeevamrit, ghanjeevamrit and beejamrit) for different parameters and found that it varies at different interval days. This present article mainly focused on the different cropping system of the natural farming and also evaluating the economics of the returns with the conventional farming system. Therefore, the cropping system practiced are Maize and soybean during kharif season followed by vegetable pea and coriander during the rabi season. Result for the different natural farming practices in soybean + maize intercropping revealed that the maximum sole yield was recorded under AI-NPOF packages with 26.1 q/ha followed by complete natural farming with 21.4 q/ha whereas other treatments remained non-significant. In intercropping, the yield was found to be maximum under complete natural farming with (35.9 q/ha). The system BC ratio was highest under AI-NPOF Packages (1.82) followed by complete natural farming (1.20). In the pea-coriander system, the higher sole yield was recorded under AI-NPOF package with (70 q/ha) followed by complete NF (61.4 q/ha). The intercropping yield and vegetable pea equivalent were highest under complete NF. The result indicated that in natural farming, the vegetable-based cropping system was profitable in comparison to the maize based in terms of the net returns.

Introduction
The agriculture in India where the green revolution was popularized has severely affected the soil health to a great extent. The liberal usage of fertilizers and inorganic substances has significantly raised the production and yield while creating the bad soil health. With this application, there has been a rise in the intake of the N, P and K from 0.07 million tons to more than 25.95 million tons. Due to the heavy dosage application of fertilizers, there has been an imbalance in soil health where the soil flora has greatly been affected (Khadse et al. 2019). Moreover, the effect of the green revolution has always left its harmful footprints in the agricultural era. The monocropping system practiced in India has also encouraged the application of fertilizers and pesticides in a higher quantity causing considerable damages in the soil flora and fauna. A chemical free and climate resilient method of farming given by scientist Subash Palenkar inorder to end the problems arising after green revolution by introducing natural farming was done in the year 2006. To get the better of the problems related to soil health and production, the introduction of the organic and natural farming was introduced initially by the farmers in some pockets of the country. The natural farming is also known as Bharatiya Prakritik Krishi Paddhati Programme (BPKP) which mainly focuses at promoting traditional indigenous practices which lessens the external expenses. It is therefore based on farm biomass recycling by using the biomass mulching, use of the liquid concoction prepared from cow dung-urine and botanicals formulations. It then will reduce the dependency on external purchased inputs and will ultimately help to wave off the credit burden of small margin farmers. These farming were innovative and eco friendly that was easily accepted by many. Most of the researchers along with scientist accepted and claimed that the natural farming can be a good alternative to chemical farming that will directly help in the sustainable development.

The primarily goal of natural farming is to maximize the yield of the farm by optimizing the production factors such as labor, soil and other equipments and avoiding the use of the non-natural inputs such as fertilizers in order to maximize the production potential. Moreover, the natural farming aims to improve and preserve the soil quality whereas the conventional farming ruin in every case. Among the important steps in natural farming are the crop diversity conservation, no tillage and water shed management. Further in 2015-16, the Government of Sikkim launched the Zero Budget Natural farming (ZBNF) programme under the Ministry of Agriculture & Farmers’ Welfare, Government of India.

Keywords: Natural farming, Low input farming, cropping system, cost effective, economics

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Andhra Pradesh implemented a Zero budget farming program to enhance the farmer’s welfare and conserve the environment. Zero Budget Natural Farming is the form of farming that witnesses the natural growth of the crops without adding the fertilizers and pesticides or any other synthetic products. The main aim of the natural farming is to minimize the cost of production to almost zero and to bounce back to the pre-green revolution farming system\textsuperscript{14, 15}. Further it can be regarded as the natural farming, the intercropping with the legumes and insecticides -ing system during the Kharif and vegetable seasons. Vegetable pea and coriander under Rabi seasons. The experiment was started during the year 2020-2021 at the ICAR Research farm, Sikkim centre, Tadong Gangtok. The experiment was designed to evaluate the yield of the different crop grown under two different seasons. There were two different crops i.e. soybean and maize under Kharif seasons followed by vegetable pea and coriander under Rabi seasons. The experiment was laid out in completely Randomized Design. The below table depicts the different treatments as per the seasons (Table 1).

### Table 1. The treatment details of the natural farming experiment under study

<table>
<thead>
<tr>
<th>S. no.</th>
<th>Treatment</th>
<th>Kharif crops (Soybean + maize)</th>
<th>Rabi crops (Vegetable pea + Coriander)</th>
</tr>
</thead>
<tbody>
<tr>
<td>T\textsubscript{1}</td>
<td>Control</td>
<td>Sole crop (Soybean) (No addition of any inputs except labour for operations including weeding)</td>
<td>Sole crop (Vegetable pea) (No addition of any inputs except labour for operations including weeding)</td>
</tr>
<tr>
<td>T\textsubscript{2}</td>
<td>Complete NF</td>
<td>Soybean + Maize (intercrop) Beejamrit + Ghanjeevamrit @ 250 kg/ha + Jeevamrit @ 500 lit/ha/irrigation twice in a month + Wheat straw as mulch @ 5 t/ha + Whapasa (irrigation in alternate furrows at noon)</td>
<td>Vegetable pea + Coriander (Intercrop) Beejamrit + Ghanjeevamrit @ 250 kg/ha + Jeevamrit @ 500 lit/ha/irrigation twice in a month + soybean straw as mulch @ 5 t/ha + Whapasa (irrigation in alternate furrows at noon)</td>
</tr>
<tr>
<td>T\textsubscript{3}</td>
<td>NF-1 (Without-Beejamrit + Ghanjeevamrit + Jeevamrit)</td>
<td>Soybean + Maize (intercrop) Mulching (wheat straw as mulch @ 5 t/ha) Whapasa (irrigation in alternate furrows at noon)</td>
<td>Vegetable pea + Coriander (Intercrop) Mulching (Soybean straw as mulch @ 5 t/ha) Whapasa (irrigation in alternate furrows at noon)</td>
</tr>
<tr>
<td>T\textsubscript{4}</td>
<td>NF-2 (Without-crop residue mulching)</td>
<td>Soybean + Maize (intercrop) Beejamrit + Ghanjeevamrit @ 250 kg/ha + Jeevamrit @ 500 lit/ha/irrigation twice in a month + Whapasa (irrigation in alternate furrows at noon)</td>
<td>Vegetable pea + Coriander (Intercrop) Beejamrit + Ghanjeevamrit @ 250 kg/ha + Jeevamrit @ 500 lit/ha/irrigation twice in a month + Whapasa (irrigation in alternate furrows at noon)</td>
</tr>
<tr>
<td>T\textsubscript{5}</td>
<td>NF-3 (Without intercropping)</td>
<td>Sole crop (Soybean) Beejamrit + Ghanjeevamrit @ 250 kg/ha + Jeevamrit @ 500 lit/ha/irrigation twice in a month + Wheat straw as mulch@5t/ha + Whapasa (irrigation in alternate furrows at noon)</td>
<td>Sole crop (Vegetable pea) Beejamrit + Ghanjeevamrit @ 250 kg/ha + Jeevamrit @ 500 lit/ha/irrigation twice in a month + soybean straw as mulch @ 5 t/ha + Whapasa (irrigation in alternate furrows at noon)</td>
</tr>
<tr>
<td>T\textsubscript{6}</td>
<td>NF-4 (Without-Whapasa, irrigating in alternate rows)</td>
<td>Soybean + Maize (intercrop) Beejamrit + Ghanjeevamrit @ 250kg/ha + Jeevamrit @ 500 lit/ha/irrigation twice in a month + Wheat straw as mulch @ 5 t/ha</td>
<td>Vegetable pea + Coriander (Intercrop) Beejamrit + Ghanjeevamrit @250 kg/ha + Jeevamrit @ 500 lit/ha/irrigation twice in a month + Whapasa (irrigation in alternate furrows at noon)</td>
</tr>
</tbody>
</table>
Preparation of Jeevamrit
The Jeevamrit preparation was done at ICAR, Research farm Sikkim centre Tadong Gangtok. It was prepared in a plastic drum of 250 liters capacity where all the components mentioned were added and stirred thoroughly. Firstly, the adding of 10 kg of fresh cow (indigenous) dung with 10 liters of indigenous cow urine was done followed by addition of 2 kg of Jaggary, 2 kg pulse flour (besan, Chickpea flour) along with 150 g of soil from undisturbed bunds/ forest in 200 litres of water was mixed thoroughly. The prepared liquid was then kept under shade covering with gunny bag/ cotton cloth/ plastic mosquito net. Further the Stirring of the mixture for 5-10 minutes for twice a day i.e morning and evening with wooden stick was carried on. Jeevamrit is ready for application at 9th day and it can be applied up to 12th day from its preparation. The recommended dose is 200 liters of Jeevamrit is sufficient for one acre of land.

Application of Jeevamritha
It was generally applied to the crops twice a month in the irrigation water or as a 10% foliar spray. The preparation was stored up to a maximum of 15 days and used in the field either through spray or mixing with irrigation water.

Preparation of Beejamritam
The ingredient required to prepare beejamritam are local cow dung, cow urine, lime and soil. The cow dung was properly mixed with soil and lime which was further dipped in the cow urine for 12 hours. The cow dung was then removed from the cow urine which was squeezed and the urine was added with 50g of lime. It is basically used for the seed treatment by mixing with hand or coat the seeds well before sowing. In case of leguminous seeds, dipping them and drying is recommended.

Acchadana-Mulching
In the present experiment, the mulch material used were the crop residue of the previous sowing. Such as, the soybean and maize mulch was used for the vegetable pea and coriander cropping and the pea residue for maize and soybean cropping. It was used to protect the topsoil and promotes aeration and water retention in the soil.

Result and Discussion
The data for the soil properties after the harvest is presented in the table 2 below. After the analysis of the soil sample, the result revealed that the highest pH level was observed in case of the T7 (AI-NPOF packages) with 5.49 followed by T2 (complete natural farming) with 5.31 and 5.27 in case of T5 (NF-3). Whereas the lowest pH was recorded in T1 (Control). However, it was found that all the treatment was found to be significant. Likewise, it was also recorded that the SOC% were maximum in case of T7 (AI-NPOF packages) with 1.01% followed by T2 (complete natural farming) with 0.97% and T5 (Natural farming-3(NF-3). The lowest SOC % was found in T1 (Control). Further it was found that all the treatments were non-significant in comparison to T7. The present findings have been confirmed by many previous studies. It was revealed that the application of the organic manures to the soil will definitely influence the soil properties especially SOC% and the microbial count. It was stated that the no tillage will not increase the SOC% of the soil which in the present study was reported in case of complete natural farming. The MCB were found to be maximum in case of T7 with the highest count of 502.5 mg/kg similarly the count in T2 was 425.38 mg/kg followed by 402.56 mg/kg in case of T5.

Likewise, the lowest MCB count was observed in T1. The treatments were found to be non-significant in comparison with T7. The finding comes with an agreement with the present study as it states that the application of 100% organic manure helps in the increases of the microbial population as reported in present study. Different organic manure with different concentration affects the microbial count in a soil. The application of the FYM will help to increase the microbial population significantly. The available Nitrogen content was found to be highest in (T7) Al-NPOF with 389.46 kg/ha followed by 327.81 kg/ha in case of complete natural farming(T2) followed by natural farming-3(T5) with 319.71kg/ha.

Similarly, the available Phosphorous content in the soil was found to be maximum in T7 (AI-NPOF) with 16.69 kg/ha followed by T2 completed natural farming with 12.98 kg/ha and 12.62kg/ha in T5 (Natural farming-3). T7 (AI-NPOF packages) had the maximum available potassium which was 437.83 kg/ha followed by 419.49 kg/ha in case of T2 (complete natural farming) and 407.38 kg/ha in T5 (Natural Farming-3). Similarly, the lowest amount of potassium was observed in T3 (NF-1(without Beejamrit + Ghanjeevamrit + jeevamrit) with 395.03 kg/ha. The dehydrogenase was found to be maximum in T7 with 56.37 µg TPF produced g⁻¹ hr⁻¹ followed by T2 with 41.81 and 38.17 µg TPF produced g⁻¹ hr⁻¹ respectively in case of T5. The lowest dehydrogenase activity was recorded in T3 with 32.47 µg TPF produced g⁻¹ hr⁻¹. The bulk density was found to be maximum in T3 (NF-1 without Beejamrit + Ghanjeevamrit + jeevamrit) with 1.36 µg/m³ followed by T4 (NF-4 without waspasa, irrigation in alternative rows during noon) and T6 (NF-4 without waspasa, irrigation in alternative rows during noon) with 1.35 µg/m³. Whereas the minimum bulk
density was recorded in case of T3 (AI-NPOF) packages with 1.29 µg/m². Pareek and Yadav 2011 reported that enzyme activity was significantly increased by the application of the organic manure to the soil. Likewise, the increase of the dehydrogenase activity was maximum when the incorporation of the vermicompost followed by FYM, the findings are in agreement with the present one.

Table 2. Effect of different natural farming practices on soil properties after harvesting of last crop (Gangtok) recorded under complete T2 (Complete NF) with 38.7q/ha which was statistically at par with T4 and T6 but other treatments were found to be non-significant. The system gross returns were found to be maximum in T2 (Complete NF) with 148 Rs/ha which was statistically at par with T3 but significantly higher than other treatments. The system cost of cultivation was found to be highest in T2 (Complete NF) with 67.5 Rs/ha. Highest system cost of cultivation was recorded under T3 (Complete NF) which was statistically at par with T4 (NF-2 without crop residue mulching) but remained significantly higher than other treatments. In case of system net returns the T2 (Complete NF) were found to be significantly higher than other treatments. The system BC ratio was found to be highest under T7 (AI-NPOF Packages) with 1.82 followed by T2 (Complete natural farming) with 1.20 whereas all other treatments remained non-significant.

Table 3. Effect of different natural farming practices on productivity and profitability of crops in soybean + maize intercropping system

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sole Yield (q/ha)</th>
<th>Intercrop Yield (q/ha)</th>
<th>Soybean Equivalent Yield (q/ha)</th>
<th>System Equivalent Yield (q/ha)</th>
<th>System Gross Return (Rs/ha × 1000)</th>
<th>System Cost of Cultivation (Rs/ha × 1000)</th>
<th>System Net Return (Rs/ha × 1000)</th>
<th>System B: C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1: Control</td>
<td>16.2</td>
<td>0.0</td>
<td>0.0</td>
<td>16.2</td>
<td>62.0</td>
<td>29.6</td>
<td>32.355</td>
<td>1.09</td>
</tr>
<tr>
<td>T2: Complete NF</td>
<td>21.4</td>
<td>35.9</td>
<td>17.3</td>
<td>38.7</td>
<td>148.3</td>
<td>67.5</td>
<td>80.789</td>
<td>1.20</td>
</tr>
<tr>
<td>T3: NF-1 (without Beejamrit + Ghanjeevamrit + Jeevamrit)</td>
<td>18.6</td>
<td>31.3</td>
<td>15.1</td>
<td>33.7</td>
<td>129.1</td>
<td>58.9</td>
<td>70.205</td>
<td>1.19</td>
</tr>
<tr>
<td>T4: NF-2 (without crop residue mulching)</td>
<td>19.2</td>
<td>32.7</td>
<td>15.8</td>
<td>35.0</td>
<td>134.0</td>
<td>62.0</td>
<td>71.943</td>
<td>1.16</td>
</tr>
<tr>
<td>T5: NF-3 (without intercropping)</td>
<td>20.4</td>
<td>0.0</td>
<td>0.0</td>
<td>20.4</td>
<td>78.1</td>
<td>36.7</td>
<td>41.366</td>
<td>1.13</td>
</tr>
<tr>
<td>T6: NF-4</td>
<td>19.6</td>
<td>33.2</td>
<td>16.0</td>
<td>35.6</td>
<td>136.4</td>
<td>68.1</td>
<td>168.345</td>
<td>1.00</td>
</tr>
</tbody>
</table>

(without Beejamrit + Ghanjeevamrit + Jeevamrit); T4=NF-2 (without crop residue mulching); T3= NF-3 (without intercropping); T5= NF-4 (without wasapa, irrigation in alternative rows during noon); T7=AI-NPOF Package.

From the below table 3, the result for the different natural farming practices in soybean + maize intercropping revealed that the maximum sole yield was recorded under (T7) AI-NPOF packages with 26.1 q/ha followed by (T3) complete natural farming with 21.4q/ha whereas other treatments remained non-significant. Similarly, the lowest yield was recorded in T1 (control) with 16.2 q/ha. In case of intercropping, the yield was found to be maximum under complete Natural farming (T2) with 35.9 q/ha followed by T6 (NF-4) with 33.2 q/ha. There was no yield in case of T1 (control), T3 (NF-3) (without intercropping) and T7 (AI-NPOF packages) respectively. Maximum system equivalent yield was
According to the table 4 presented below, the result concluded with the maximum sole yield which was recorded under T\(_7\) (AI-NPOF package) with 70q/ha followed by T\(_2\) (Complete NF) with 61.4 q/ha. Whereas the lowest yield was recorded in T\(_1\) (control) with 56.29q/ha. The intercropping yield and vegetable pea equivalent were found to be highest under T\(_2\) (Complete NF). The treatments such as T\(_7\) (AI-NPOF packages), T\(_5\) NF-3(without intercropping) and T\(_1\) (Control) did not yield as the yield was 0.0. With references to the system equivalent yield, maximum was recorded under T\(_2\) (complete NF) which was statistically at par with T\(_3\) (NF-1; without Beejamrit + Ghanjeevamrit + Jeevamrit) and T\(_4\) (NF-2 without crop residue mulching but significantly higher than other treatments expect T\(_6\) (NF-4 without wapasa, irrigation in alternative rows during noon) in case of system gross return, the maximum return was noticed under T\(_2\) (complete NF) which was significantly higher in comparison to other treatments but remained at par with T\(_3\), T\(_4\) and T\(_6\). System cost of cultivation was recorded to be maximum under T\(_6\) which was statistically higher than other treatments expect T\(_4\) which was found to be significant. The system net return was found to be highest in complete NF. The maximum B: C ratio was noticed under AI-NPOF packages followed by complete NF which was significantly higher than other treatment but remained at par with T\(_6\).

**Table 4. Effect of different natural farming practices on productivity and profitability of crops in vegetable pea + coriander intercropping system**

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Sole Yield (q/ha)</th>
<th>Intercrop Yield (q/ha)</th>
<th>Vegetable Pea Equivalent Yield (q/ha)</th>
<th>System Equivalent Yield (q/ha)</th>
<th>System Gross Return (Rs/ha) x 1000</th>
<th>System Cost of Cultivation (Rs/ha) x 1000</th>
<th>System Net Return (Rs/ha) x 1000</th>
<th>System B: C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1: Control</td>
<td>56.2</td>
<td>0.00</td>
<td>0.0</td>
<td>56.2</td>
<td>168.6</td>
<td>43.4</td>
<td>125.1</td>
<td>2.88</td>
</tr>
<tr>
<td>T2: Complete NF</td>
<td>61.4</td>
<td>5.12</td>
<td>17.1</td>
<td>78.5</td>
<td>235.4</td>
<td>51.1</td>
<td>184.2</td>
<td>3.60</td>
</tr>
<tr>
<td>T3: NF-1 (without Beejamrit + Ghanjeevamrit + Jeevamrit)</td>
<td>58.6</td>
<td>4.10</td>
<td>13.7</td>
<td>72.3</td>
<td>216.8</td>
<td>46.8</td>
<td>169.9</td>
<td>3.63</td>
</tr>
<tr>
<td>T4: NF-2 (without crop residue mulching)</td>
<td>59.2</td>
<td>4.42</td>
<td>14.7</td>
<td>73.9</td>
<td>221.8</td>
<td>48.4</td>
<td>173.3</td>
<td>3.58</td>
</tr>
<tr>
<td>T5: NF-3 (without intercropping)</td>
<td>60.4</td>
<td>0.00</td>
<td>0.0</td>
<td>60.4</td>
<td>181.2</td>
<td>47.1</td>
<td>134.0</td>
<td>2.85</td>
</tr>
<tr>
<td>T6: NF-4 (without Whapasa, irrigating in alternate rows and during noon)</td>
<td>59.6</td>
<td>4.87</td>
<td>16.2</td>
<td>75.8</td>
<td>227.5</td>
<td>51.4</td>
<td>176.0</td>
<td>3.42</td>
</tr>
<tr>
<td>T7: AI-NPOF package</td>
<td>70.0</td>
<td>0.00</td>
<td>0.0</td>
<td>70.0</td>
<td>210.0</td>
<td>45.2</td>
<td>164.8</td>
<td>3.64</td>
</tr>
</tbody>
</table>

According to the table 4 presented below, the result concluded with the maximum sole yield which was recorded under T\(_7\) (AI-NPOF package) with 70q/ha followed by T\(_2\) (Complete NF) with 61.4 q/ha. Whereas the lowest yield was recorded in T\(_1\) (control) with 56.29q/ha. The intercropping yield and vegetable pea equivalent were found to be highest under T\(_2\) (Complete NF). The treatments such as T\(_7\) (AI-NPOF packages), T\(_5\) NF-3(without intercropping) and T\(_1\) (Control) did not yield as the yield was 0.0. With references to the system equivalent yield, maximum was recorded under T\(_2\) (complete NF) which was statistically at par with T\(_3\) (NF-1; without Beejamrit + Ghanjeevamrit + Jeevamrit) and T\(_4\) (NF-2 without crop residue mulching but significantly higher than other treatments expect T\(_6\) (NF-4 without wapasa, irrigation in alternative rows during noon). In case of system gross return, the maximum return was noticed under T\(_2\) (complete NF) which was significantly higher in comparison to other treatments but remained at par with T\(_3\), T\(_4\) and T\(_6\). System cost of cultivation was recorded to be maximum in T\(_6\) which was statistically higher than other treatments expect T\(_4\) which was found to be significant. The system net return was found to be highest in complete NF. The maximum B: C ratio was noticed under AI-NPOF packages followed by complete NF which was significantly higher than other treatment but remained at par with T\(_6\).
the organic farming system as well. The liquid concoction used as the remedy for the major insect pest will be dominance aspects in the farming system where the total discard of the in organic product is done. Further it can be concluded that the application jeemamrita and beejamritham in the field can be a very useful component as they efficiently and naturally works as a seed treatment along with the insect-pest repellent. Moreover, the preparations of these products are easy to prepare with less inputs within a short frame of time.

Natural farming is found not popular among the farmers in Sikkim. Although the state is an organic one, the certain certain practices prescribed in natural farming, such as Jeevamritha, Beejamritha and other plant protection materials. Mulching and different irrigation techniques (Wapasa) can be introduced. There is always scope for tweaking and innovation in these practices like Ghanajeevamritha in Sikkim. It is also evident that there is significant reduction in the cost of cultivation of all the crops, although crop yield may/may not be higher as compared to conventional farming. Further, the observed of better soil health in terms of light texture, presence of earthworms, moisture retention, etc. in natural farming plot can be experienced. Thus, natural farming may not look as yield enhancing farming practices, but would definitely increase farmers’ income through cost reduction and long-term sustainability.

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Declaration of interests

The authors have no conflict of interest to declare.

Data sharing

All relevant data are within the manuscript

References