Earthworms are considered as the most important soil invertebrates in terms of biomass and activity. Several studies have emphasized the importance of earthworms in consumption and degradation of litter and incorporating plant residues in the upper soil horizon. They can consume 30% of their own weight per day. According to researchers, earthworm cast can positively affect plant growth in the tropics, due to higher concentration of plant available nutrients. Thus the activities of earthworms have been shown to enhance plant yield because of their beneficial effects on soil properties.

Vermiculture scientists all over the world knew about the role of earthworms as waste managers, soil managers, fertility improvers and plant growth promoters for a long time. Now researches are being done to know which are the best organic substrates among the diverse organic waste that can produce the most nutritive vermicompost competing with chemical fertilizer and the best methods of vermicomposting including the selection of composting worms that can give rapid and good results. With similar objective the present study has been conducted to (i) evaluate the changes in the properties of the vermicomposts when produced by three different earthworm species viz: Drawida nepalensis, Metaphire houlleti and Perionyx excavates and its effect on wheat plant growth. The result shows that organic carbon content was found within the range of 25.52% to 28.82%. While organic nitrogen was noted in between 1.85% to 1.98% for the three vermicomposts type and the C: N ratio was found to be 13.79 to 14.77. The crop growth parameters were found maximum for vermicomposts treatment with respect to control treatment. The plant height parameter shows significant increase of 12.78%, 16.59% and 20.49% when treated with the vermicomposts produced by Drawida nepalensis, Metaphire houlleti and Perionyx excavates with respect to control.

MATERIALS AND METHODS

The earthworms were sampled from 15 dug pits of the size 25x25x30 cms. randomly on regular monthly basis for two years from Narayankoti district Rudraprayag (29°30’3” N and 79°77’02” E and altitude ranges 1200-1800 msl). Then the earthworms of the species Drawida nepalensis, Metaphire houlleti and Perionyx excavates were cultured in 3 experimental pits having size 1.5x0.5x0.5 m partially decomposed cattle dung with partially decomposed agricultural refuse used in equal amounts (w/w). The 3 earthworm species with 80 individuals/pit were introduced separately in pit 1, pit 2 and pit 3 respectively. 40-50% of moisture and regular water supply should be maintained in the pits to retain moisture level.

The finished vermicompost obtained after 75 days were dried, grinded and sieved at 2mm sieve and were analyzed as per standard methods. Moisture content was calculated as percent of the weight after oven drying at 105o Celsius. pH by a digital pH meter in 1:2.5 soil/water solution. Soil nitrogen was analyzed by the microkjeldahl method. Available phosphate was measured spectrophotometrically by the molybdenum blue method after extraction with sodium bicarbonate extracting solution. Potassium by flame photometer method after extraction with ammonium acetate buffer at pH 7.
Now to study the effects of vermicomposts on wheat plant four plots of size 1mx1m were taken. Indigenous variety of wheat k-68 was sown to all the four plots. Then VDn (Vermicompost of Drawida Nepalensis), VMh (Vermicompost of Metaphire houlleti), VPe ((Vermicompost of Perionyx excavates), were applied @ 10 t/h or 1kg/m2 to plot 1,2,3 and plot 4 was taken as control (without vermicompost). The vermicompost were applied in two splits during the study period (i) at the time of sowing of seeds and again when plants have attained a knee high stage. At the time of crop harvest the wheat plants were taken out of the plot and growth performances were noted with respect to five parameters (i) plant height in cms (ii) number of tillers per plant (iii)ear size in cms (iv) dry weight of plant excluding ears in gms (v) dry weight of ears per plant (in gms).

RESULTS AND DISCUSSION

The three species of earthworms D. nepalensis, M. houlleti and P. excavates were maintained and utilized for the stabilization of the agriculture refuse. The data on the physico-chemical properties of the three vermicompost are presented in Table-1. However the data on effects of three types of vermicompost on the growth of wheat plant with respect to control are presented in Table-2.

No significant differences were found within the physico-chemical properties of the three vermicompost types. The vermicompost of the three species i.e. VDn, VMh and VPe contain moisture percent 43.85%, 51.3% and 50.2 % respectively, which was in accordance with the preferred range of moisture in finished compost i.e. 40-45% by Dougherty. In vermicomposting process the moisture content is usually kept within the range so that it can fulfill the needs of microbes and earthworms, while Lofs-Holmin and Edwards and Neuhauser suggested that the vermibeds in which the process of vermicomposting ongoing needs to have moisture content in between 60-90%. workers reported that 67% moisture content is appropriate for the vermicomposts. pH is the numerical measure of acidity and alkalinity or hydrogen ion concentration of a material during present study the pH recorded within 5.6-5.9 which were found to be acidic. As active caliciferous glands in the earthworms contain large quantities of carbonic anhydrate which catalyze the fixation of CO2 in the form calcium carbonate. Thus results the fall in p of the body fluid. Tolerance of soil pH varies from species to species in earth worms, usually they can live in soils with pH ranging from 4.5-8.7, but neutral soils have greater density of earthworms as compared to alkaline and acidic soils. Several workers concluded that earthworms decompose organic matter quickly and the vermicompost formed which contain more carbon content than the parent soil. The organic carbon content was found within the range of 25.52% for VMh - 28.82% for VPe. Organic matter content in the composting material showed a decrease towards maturity due to the degradation by microorganism. Nitrogen content ranges in between 1.85% - 1.98%. It has been reported that earthworms increases the nitrate production by stimulating bacterial activity and through decomposition of their own bodies. Researchers found that microbial activity in the gut of earthworms improves level of nitrogen present. Phosphorus and Potassium were found maximum for VMh and VDn respectively. Many studies have shown that the earthworms cast have increased concentration of these elements or they have been transformed to accessible form for plant uptake. The ratio of carbon to nitrogen in organic matter added to soil is very important since plant can't assimilate mineral nitrogen. Earthworms profoundly affect microbial activities and organic matter dynamics in soil that passes through their gut, which seems to be the most important factor in the development of sustainable earthworm distribution. The C: N ratio of the vermicomposts was found higher in VPe than that of VDn and VMh. Workers studied changes in chemical properties during composting of organic residues as influenced by earthworm activity. According to them there was a decrease in C: N ratio. The organic carbon was lost as CO2 and N content of compost is decomposed on the initial N present in the waste and extent of decomposition. Some worker have reported higher content and micronutrient in vermicompost.

The result on crop growth experiment showed that compared to the control total plant height, dry weight of plants and dry weight of ears/plant was found higher in vermicompost treatments. Plant height was increased significantly (F 3,8 = 50.25, P<0.01) 12.78% in VDn, 16.59% in VMh and 20.49% in VPe. Dry weight of plant (excluding ear) were also showed a significant (F3,8 = 4.68, P<0.05) increase of 20.30% with VDn, 31.30% with VMh and 43.01% with VPe compared to control. In continuation of this the dry weight of ears/plant showed an increase of 21.74%, 24.64% and 36.76% when treated with VDn, VMh and VPe respectively. It is due to application of vermicomposts which improves the physical,
Table 1. Physico-chemical parameter of the three vermicomposts.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>VDn</th>
<th>VMh</th>
<th>VPe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture %</td>
<td>45.8 ± 3.6</td>
<td>51.3 ± 4.8</td>
<td>50.5 ± 4.2</td>
</tr>
<tr>
<td>pH</td>
<td>5.8 ± 0.05</td>
<td>5.9 ± 0.06</td>
<td>5.6 ± 0.04</td>
</tr>
<tr>
<td>Org. carbon%</td>
<td>27.64 ± 1.6</td>
<td>25.52 ± 1.4</td>
<td>28.8 ± 2.17</td>
</tr>
<tr>
<td>Nitrogen %</td>
<td>1.98 ± 0.02</td>
<td>1.85 ± 0.03</td>
<td>1.95 ± 0.05</td>
</tr>
<tr>
<td>Phosphorus %</td>
<td>0.108 ± 0.0003</td>
<td>0.138 ± 0.0006</td>
<td>0.117 ± 0.0006</td>
</tr>
<tr>
<td>Potassium %</td>
<td>0.028 ± 0.0002</td>
<td>0.026 ± 0.0003</td>
<td>0.024 ± 0.0001</td>
</tr>
<tr>
<td>C:N</td>
<td>13.59 ± 1.2</td>
<td>13.79 ± 1.1</td>
<td>14.77 ± 1.3</td>
</tr>
</tbody>
</table>

Table 2. Effect of the three vermicomposts on growth parameter of wheat plants with respect to control.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Plot 1 (VDn)</th>
<th>Plot 2 (VMh)</th>
<th>Plot 3 (VPe)</th>
<th>Plot 5 (control)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant height (cms)</td>
<td>103.02 ± 3.2*</td>
<td>106.50 ± 4.6*</td>
<td>110.06 ± 3.6*</td>
<td>91.34 ± 6.5*</td>
</tr>
<tr>
<td>Number of tillers/plant</td>
<td>5.6 ± 1.1</td>
<td>4.8 ± 1.2</td>
<td>5.2 ± 1.4</td>
<td>4.4 ± 1.8</td>
</tr>
<tr>
<td>Ear size (cms)</td>
<td>4.84 ± 2.3</td>
<td>5.62 ± 2.1</td>
<td>6.62 ± 2.2</td>
<td>4.62 ± 2.1</td>
</tr>
<tr>
<td>Dry weight of plant excluding ears (gms)</td>
<td>14.99 ± 3.4**</td>
<td>16.36 ± 5.2**</td>
<td>17.82 ± 5.3**</td>
<td>12.46 ± 3.6**</td>
</tr>
<tr>
<td>Dry weight of ears/plant (gms)</td>
<td>14.67 ± 5.2</td>
<td>15.02 ± 4.8</td>
<td>16.48 ± 5.2</td>
<td>12.05 ± 4.2</td>
</tr>
</tbody>
</table>

[*Significant at P<0.01.**Significant at P<0.05]

chemical and biological conditions of the soil. Vermicast provides a potentially significant source of readily available nutrients for plant growth and thereby increasing growth of wheat plants with all the three types of vermicomposts. There have been several reports that earthworm and its vermicomposts can induce excellent plant growth and promote good crop production without chemical fertilizers. Glasshouse studies made at CSIRO Australia found that the earthworms (Aporrectodea trapezoids) increased growth of wheat crops by 39%, grain yield by 35%, lifted protein value of grain by 12% and also resisted crop diseases as compared to the control.

Studies on agronomic impact of vermicomposts on cherries found that it increased yield of cherries for three years after single application inferring that the use of vermicompost in soil builds up fertility and restore its vitality for long time contrary to chemical fertilizers.

ACKNOWLEDGEMENT

Authors are thankful to Dr J.M. Julka (Scientist) ZSI, Solan, for identifying the earthworms and GBPIHED, Garhwal unit, Srinagar Garhwal for providing Lab facilities.

REFERENCES

6. Bisht, R., Pandey, H., Bisht, S.P.S., Kandpal, B. and