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INFLUENCE OF VERMICOMPOST ON QUALITY OF POTATO (*SOLANUM TUBEROSUM*) IN WET TEMPERATE ZONE OF HIMACHAL PRADESH

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SUMMARY

An experiment was carried out at the research farm of the Department of Soil Science, CSKHPKV, Palampur during *Rabi* 2006 to study the effect of organic manures and chemical fertilizers on quality and productivity of potato. The experimental soil was silty clay loam in texture, acidic in reaction (pH 5.8), high in organic carbon, low in available N and medium in available P and K. Fourteen treatment combinations comprising vermicompost or farmyard manure alone, 100 % NPK (120:35:50 kg/ha) alone, conjoint use of vermicompost or farmyard manure and chemical fertilizers and absolute control were laid out in randomized block design with 3 replications. Highest contents of starch (13.20%), protein (10.94%), ascorbic acid (24.36 mg/100g), N (1.75%), P (0.290%), K (1.21%), Fe (161.46 ppm), Mn (50.98 ppm), Zn (29.83 ppm) and Cu (12.53 ppm) were recorded in the treatment comprising 100% NPK + 25 tonnes vermicompost/ha. The results demonstrated that conjoint application of chemical fertilizers and organic manures recorded significantly higher contents of different quality parameters than sole use of inorganic fertilizers. The contents of biochemical components namely starch, protein and ascorbic acid under 100% NPK + 25 tonnes vermicompost /ha were higher by 15.8, 12.5 and 8.3 % over 100% NPK and the corresponding increase in case of mineral constituents viz. N, P, K, Mn, Zn and Cu were 15.9, 8.6, 15.2, 59.9, 22.2, 24.2, 8.2 %. Furthermore, the contents of ascorbic acid were higher under the treatments involving organics and even sole use of organics recorded higher ascorbic acid contents than 100% NPK alone. Application of 100% NPK + 25 tonnes vermicompost/ha recorded 42.4 % higher tuber yield than 100 % NPK alone. The results suggested that integrated use of vermicompost along with inorganic fertilizers is an important nutrient management option of improving the quality and productivity of potato.

Key words: **Organics, potato (*Solanum tuberosum*), quality, vermicompost, yield**

INTRODUCTION

It is well recognized that fertilizers are playing a significant role in tackling the problem of food security of the country. However, it has been realized of late that indiscriminate use of chemical fertilizers has affected the soil quality adversely in terms of decreasing organic carbon contents and development of micronutrient deficiencies and ultimately culminating into deterioration of produce quality (Khurana and Naik 2003). This calls for the immediate attention of researchers to evolve nutrient management strategies solving the problems of food security and crop quality in holistic manner. Potato (*Solanum tuberosum*) is a main cash crop of Himachal Pradesh occupying an area of 14, 000 ha (Anonymous 2005-2006). Many studies have been conducted to evaluate the effect of nutrient management on potato productivity but the information on the effect of

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vermicompost particularly on quality *per se* is scanty. It is worth mentioning here that vermicompost is emerging manure in present day agriculture. Keeping these facts in view, the present study was planned to evaluate the performance of vermicompost in terms of quality and productivity of potato and to compare it with the traditional manure *i.e.* farmyard manure. As no systematic study had so far been conducted to compare the efficiency of vermicompost in relation to farmyard manure in wet temperate zone of Himachal Pradesh the present investigation was undertaken to generate the lacking information.

MATERIALS AND METHODS

A field trial was conducted during *Rabi* 2006 at the Research Farm of the Department of Soil Science, CSKHPKV, Palampur. The experimental site is situated at $32^0$6'N latitude and $73^0$3'E longitude at an elevation of about 1290 m above mean sea level. The area lies in the high rainfall mid hill wet temperate zone of Himachal Pradesh in North – west Himalaya. The soil was silty clay loam in texture having acidic reaction (pH 5.8), high organic carbon (1.2%), low available N (220 kg/ha), medium P (16.2 kg/ha) and K (268 kg/ha). The experiment was laid out in randomized block design with 3 replications and fourteen treatments *viz*., control (T_1), 100% NPK (T_2), 12.5 tonnes farmyard manure/ha (T_3), 25 tonnes farmyard manure/ha (T_4), 12.5 tonnes vermicompost /ha (T_5), 25 tonnes vermicompost /ha (T_6), 75% NPK + 12.5 tonnes farmyard manure/ha (T_7), 75% NPK + 25 tonnes farmyard manure/ha (T_8), 75% NPK + 12.5 tonnes vermicompost/ha (T_9), 75% NPK + 25 tonnes vermicompost/ha (T_{10}), 100% NPK + 12.5 tonnes farmyard manure/ha (T_{11}), 100% NPK + 25 tonnes farmyard manure/ha (T_{12}), 100% NPK + 12.5 tonnes vermicompost/ha (T_{13}), 100% NPK + 25 tonnes vermicompost/ha (T_{14}) were evaluated under irrigated conditions. Full dose of farmyard manure and vermicompost and P and K along with half of N were applied at the time of sowing. Remaining N was top-dressed at 30 days after sowing. The 100 % NPK application was equivalent to 120 kg N, 35 kg P and 50 kg K/ha respectively. Sources of N, P and K were urea, single super phosphate and muriate of potash, respectively. The tuber yield obtained from each net plot was recorded in kg/plot and then converted in tonnes/ha. The processed tuber samples from each plot were analysed separately for total nitrogen content by modified Kjeldahl's method (Jackson 1967), total P content by vanadomolybdate phosphoric acid yellow colour method (Jackson 1967), total K by Flame emission spectrophotometer (Black 1965) and micronutrients (Fe, Mn, Cu, Zn) were determined on atomic absorption spectrophotometer (Jackson 1967). Protein content in the tubers was calculated by multiplying the tuber N contents by a factor 6.25. Starch and ascorbic acid contents in tubers were determined on fresh weight basis by anthrone reagent method (Sadasivam and Manickam 1996) and 2, 6- dicholrophenol-indophenol visual titration method (Johnson 1948) respectively. Statistical analysis was done as per standard procedure.

RESULTS AND DISCUSSION

Effect on biochemical components: Use of chemical fertilizers along with organic manures increased markedly the protein contents of potato tubers. Protein contents were highest (10.94%) where vermicompost @ 25 tonnes/ha was applied along with recommended NPK which were higher by 53 % over control (Table 2). The results demonstrated that protein contents improved greatly with the successive additions of N, P, K and organic manures indicating clearly that balanced fertilization is necessary for obtaining higher protein contents. As compared to control, starch content was 16.6, 44.5 and 49.6 % more under 100 % NPK, 100 % NPK + 25 tonnes farmyard manure/ha and 100 % NPK + 25 tonnes vermicompost/ha. The increase in protein contents due to the application of chemical fertilizers (NPK) may be attributed to direct role of nitrogen in protein synthesis. Since organics do supply nitrogen on mineralization, the increase in protein content due to the addition of farmyard manure and vermicompost is understandable. Invariably, the protein contents were higher under vermicompost treatments as compared to farmyard manure treatment which may be ascribed to higher N contents of vermicompost than those of farmyard manure (Table 1). The starch contents ranged between 8.82 to 13.2 %. It is evident from the data that sole use of organics or chemical fertilizers or in combination significantly improved the starch contents of tubers (Table 2). Maximum starch contents (13.20%) were noted in the plots receiving recommended dose of

Table 1. Manurial value of vermicompost and farmyard manure used in the experiment

Parameter	Farmyard manure	Vermicompost
C (%)	43.02	34.69
N (%)	0.95	2.82
P (%)	0.62	1.14
K (%)	0.50	0.68
Ca (%)	0.22	0.42
Mg (%)	0.16	0.34
S (%)	0.11	0.26
Fe (ppm)	6503	8466
Mn (ppm)	23.94	357.00
Zn (ppm)	47.08	89.88
Cu (ppm)	31.20	55.57
Biomass C (mg kg^{-1})	138.99	153.25
Biomass N (mg kg^{-1})	23.31	40.40
Dehydrogenase activity (µg TPF g^{-1} hr^{-1})	377.95	404.59
Bacteria (cfu g^{-1})	40 x 10^5	55 x 10^5
Fungi (cfu g^{-1})	16 x 10^4	14 x 10^4
Actinomycetes (cfu g^{-1})	20 x 10^4	78 x 10^4
Dry matter (%)	36.00	62.00
pH (1:2.5)	7.85	6.35
C :N	52.83	14.35
C: P	179.25	54.64

Table 2. Effect of organic manures and fertilizers on crop quality

Treatment	Protein (%)	Starch (%)	Ascorbic acid (mg/ 100g)
T_1 Control	7.13	8.82	12.87
T_2 100 % NPK	9.44	10.29	17.16
T_3 12.5 t FYM/ha	7.44	9.85	18.59
T_4 25 t FYM/ha	7.69	10.32	20.02
T_5 12.5 t VC/ha	8.69	10.21	20.49
T_6 25 t VC/ha	8.94	10.86	21.45
T_7 75 % NPK + 12.5 t FYM/ha	10.35	10.73	19.06
T_8 75 % NPK + 25 t FYM/ha	10.69	11.17	20.49
T_9 75 % NPK + 12.5 t VC/ha	10.40	10.84	21.45
T_{10} 75 % NPK + 25 t VC/ha	10.88	11.36	22.88
T_{11} 100 % NPK + 12.5 t FYM/ha	10.50	11.56	20.02
T_{12} 100 % NPK + 25 t FYM/ha	10.75	12.75	22.40
T_{13} 100 % NPK + 12.5 t VC/ha	10.56	12.07	23.56
T_{14} 100 % NPK + 25 t VC/ha	10.94	13.20	24.36
CD (P = 0.05)	0.574	0.383	1.955

FYM, Farmyard manure VC, Vermicompost

chemical fertilizers along with 25 tonnes vermicompost/ ha which were significantly higher than 100 % NPK + 25 tonnes farmyard manure/ha (12.75 %) and 100 % NPK alone (10.29 %). Starch contents were higher by 49.6 % under treatment receiving 100 % NPK plus 25 tonnes vermicompost/ha as compared to control plot. Similar to protein contents, when farmyard manure and vermicompost were applied at the same rate, the contents were significantly higher under vermicompost application than farmyard manure treatment. The increase in starch contents either due to the application of chemical fertilizers alone or with the combined use of fertilizers and organic manures may be explained in light of increased supply of potassium through these inputs. Potassium plays an important role in the activation of starch synthetase, a key enzyme controlling the incorporation of glucose into long chain starch molecules (Tisdale *et al*. 1985). Moreover, potassium helps in translocation of starch from leaves to tubers (Sud *et al.* 1992). The beneficial effect of manure additions could be attributed to improved soil-water-air relationship, thereby, encouraging better root proliferations, resulting in higher K uptake and consequently higher starch contents (Danilchenko *et al.* 2005).

Significant increase was noted in ascorbic acid contents with the application of organic manures or chemical fertilizers either alone or in combination. Application of 100% NPK + 25 tonnes vermicompost/ ha registered highest increase (89%) in ascorbic acid

content over control. The corresponding increase under 25 tonnes vermicompost/ha and 100 % NPK was 66.6 and 33.3 % indicating clearly that use of organics was more beneficial in improving the ascorbic acid contents than the use of inorganic fertilizers. This might be attributed to the fact that increased supply of Zn through organics has suppressive effect on the activity of ascorbic acid oxidase, the enzyme responsible for the degradation of ascorbic acid content. Ascorbic acid content recorded under 100% NPK + 12.5 tonnes vermicompost/ha were at par with the treatment comprising recommended dose of nutrient i.e. 100% NPK + 25 tonnes farmyard manure/ha demonstrating thereby the superiority of vermicompost over farmyard manure. Relatively higher contents of ascorbic acid in vermicompost treated plots in comparison to farmyard manure may be ascribed to higher Zn contents of vermicompost than farmyard manure (Table 1).

Effect on mineral contents: A positive and significant effect of chemical fertilizers and organics manures was noted on the N, P and K contents of tubers when these sources of nutrients were used either alone or in combination. However, the contents of these elements were significantly higher under integrated use of organic manures and synthetic fertilizers than those recorded under sole use of either fertilizers or organic manures (vermicompost or farmyard manure). Percent increase in N, P and K contents with the application of 100% NPK + 25 tonnes vermicompost/ha over 100% NPK alone was to the order of 16, 9 and 15, respectively. The significant increase in N, P and K contents with the conjoint use of organic manures and chemical fertilizers may be attributed to the fact that the concentration of these nutrients in the soil solution might be sufficiently high due to combined application of organic manures and chemical fertilizers. Besides, better proliferation of roots under the influence of organics and inorganics might have resulted in the increased absorption of water and nutrients from larger area. Since vermicompost is a rich source of nutrients (Table 1), relatively higher NPK contents in case of vermicompost involving treatments is quite understandable.

Similar to NPK, concentration of Fe and Mn in tuber was significantly higher under the integrated use of vermicompost or farmyard manure and chemical fertilizers when compared with plots which did not receive any manures/fertilizers (Table 3). Highest concentration of Fe (174.24 ppm) and Mn (50.98 ppm) was recorded in 100 % NPK + 25 tonnes farmyard manure/ha and 100 % NPK + 25 tonnes vermicompost/ ha treated plots, respectively. These treatments registered 72.6 and 22.2 % increase in Fe and Mn contents, respectively over 100 % NPK alone. Zinc and Cu contents also registered increase under conjoint use of manures and fertilizers as compared to sole use of inorganic fertilizers but the effect was non-significant. The beneficial effect of vermicompost/ farmyard manure in increasing the concentration of micronutrients may be ascribed to direct supply of these cations on mineralization of vermicompost or farmyard manure and the solubilisation action of the organic acids produced during the decomposition of vermicompost/farmyard manure and also indirectly to the positive effect of vermicompost or farmyard manure on overall soil environment.

Effect on yield: Significant increase (313 %) in tuber yield was noted with the application of 100 % NPK alone over control (Table 4). The beneficial roles of N, P and K in increasing crop yields are well documented in theory and practice. Nitrogen is an integral part of all enzymes which stimulate and regulate multitude of biochemical events in plant system (Novoa and Loomis 1981). It is a structural constituent of plant body, chlorophyll, nucleic acid and protein. Likewise, a better supply of phosphorus has been associated with proliferous root growth resulting in enhanced water and nutrient absorption. Secondly, it is essential for laying out primordia for reproductive organs (Tisdale *et al.* 1985). Potassium helps in activation of enzymes, starch synthesis, nitrogen uptake and protein synthesis. The increase in yield was still higher with the conjoint use of organics and inorganics. The highest tuber yield (30.46 t/ha) was recorded under 100 % NPK+ 25 tonnes vermicompost/ha which was higher by 7.7 and 42.4 % as compared to 100 % NPK + 25 tonnes farmyard manure and 100 % NPK alone. Similar effect was noted on haulm yield. The positive effect of addition of manures and fertilizers on the tuber yield of potato may be attributed to direct supply of essential nutrients to the

Table 3. Effect of organic manures and fertilizers on mineral contents in potato

Treatment	N (%)	P (%)	K (%)	Fe (ppm)	Mn (ppm)	Zn (ppm)	Cu (ppm)
T_1 Control	1.14	0.230	0.91	83.24	34.97	20.48	10.36
T_2 100 % NPK	1.51	0.267	1.05	100.92	41.71	24.01	11.58
T_3 12.5 t FYM/ha	1.19	0.234	0.97	85.37	37.51	25.11	10.80
T_4 25 t FYM/ha	1.23	0.238	1.03	98.56	39.97	26.73	12.08
T_5 12.5 t VC/ha	1.39	0.238	1.00	102.12	38.41	28.56	12.61
T_6 25 t VC/ha	1.43	0.259	1.06	129.36	43.04	28.78	12.61
T_7 75 % NPK + 12.5 t FYM/ha	1.66	0.271	1.05	110.00	38.17	27.95	11.20
T_8 75 % NPK + 25 t FYM/ha	1.71	0.279	1.07	142.56	43.37	29.16	12.96
T_9 75 % NPK + 12.5 t VC/ha	1.66	0.279	1.09	148.72	44.97	27.95	11.97
T_{10} 75 % NPK + 25 t VC/ha	1.74	0.288	1.16	155.76	46.51	29.56	12.61
T_{11} 100 % NPK + 12.5 t FYM/ha	1.68	0.275	1.12	140.16	43.04	25.11	12.14
T_{12} 100 % NPK + 25 t FYM/ha	1.72	0.281	1.14	174.24	49.78	26.33	11.12
T_{13} 100 % NPK + 12.5 t VC/ha	1.69	0.283	1.18	169.04	52.91	29.16	12.72
T_{14} 100 % NPK + 25 t VC/ha	1.75	0.290	1.21	161.46	50.98	29.83	12.53
CD (P=0.05)	0.092	0.039	0.060	16.252	6.065	NS	NS

crop. Application of chemical fertilizers might have accelerated the decomposition/mineralization of organics which, in turn, released macro and micronutrients and other growth promoting substances. In addition to this, decomposition products of organics might have improved physical and biological properties of soil.

Tuber yield of potato produced under recommended dose of NPK without organics (21.34 tonnes/ha) was at par with that recorded under 25 tonnes farmyard manure/ha or 12.5 tonnes vermicompost/ha along with 75 % of recommended dose of NPK (22.96 and 22.31 tonnes/ha, respectively). It clearly indicated a substitution of fertilizer NPK to the extent of 25 % of recommended dose with the use of either 25 tonnes farmyard manure/ ha or 12.5 tonnes vermicompost/ha. Similarly, when 75 % of recommended dose of NPK along with 25 tonnes vermicompost/ha was compared with 100 % of recommended dose of NPK without organics, it was observed that addition of vermicompost (25 tonnes/ha) not only substituted 25 % of fertilizer NPK but also resulted in additional gain of 3.01 tonnes/ha which again highlighted the scope of substitution of inorganic NPK fertilizers with organic sources without loosing the yield.

When vermicompost and farmyard manure were applied at the same rate along with chemical fertilizers, the yield was higher under vermicompost treatment. For example, the increase in yield with the application of 100 % NPK + 25 tonnes vermicompost/ha and 100 % NPK + 25 tonnes farmyard manure/ha over 100 % NPK without organics was 44.61 and 32.57 %, respectively. This clearly demonstrated the superiority of vermicompost over farmyard manure. The higher productivity with the use of vermicompost in comparison to farmyard manure may be explained on the basis of higher nutrient status, biochemical ingredients and microbial activity of vermicompost (Table 1). In addition to these ingredients, vermicompost also supplies growth hormones, enzymes, antibiotics, vitamins etc. (Bhawalker 1991). Further more, it was observed that yield recorded under recommended nutrient package *i.e* 100% NPK + 25 t farmyard manure/ha was at par with that under 12.5 tonnes vermicompost/ha plus 100% NPK demonstrating

Table 4. Effect of organic manures and fertilizers on the productivity of potato

Treatment	Tuber yield	Haulm yield
	tonnes/ha	
T_1 Control	5.18	1.33
T_2 100 % NPK	21.39	5.93
T_3 12.5 t FYM/ha	7.59	2.30
T_4 25 t FYM/ha	9.81	3.33
T_5 12.5 t VC/ha	8.29	2.52
T_6 25 t VC/ha	10.28	3.56
T_7 75 % NPK + 12.5 t FYM/ha	18.33	4.81
T_8 75 % NPK + 25 t FYM/ha	22.96	6.22
T_9 75 % NPK + 12.5 t VC/ha	22.31	5.78
T_{10} 75 % NPK + 25 t VC/ha	24.40	6.74
T_{11} 100 % NPK + 12.5 t FYM/ha	25.23	6.96
T_{12} 100 % NPK + 25 t FYM/ha	28.29	7.93
T_{13} 100 % NPK + 12.5 t VC/ha	27.45	7.70
T_{14} 100 % NPK + 25 t VC/ha	30.46	9.04
CD (P = 0.05)	1.875	0.876

clearly that we can replace the existing package of 100 % NPK + 25 tonnes farmyard manure/ha with 100 % NPK + 25 tonnes vermicompost/ha.

From the present study, it can be inferred that combined use of organic manures and chemical fertilizers is necessary to improve the quality and productivity of potato. Among the manures, vermicompost is superior over traditionally used farmyard manure. We can replace the existing practice of 100 % NPK + 25 tonnes farmyard manure/ha with 12.5 tonnes vermicompost/ha plus 100 % NPK under wet temperate condition of Himachal Pradesh.

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