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Research Articles

Productivity, profitability and energetics of buckwheat (*Fagopyrum* sp.) cultivars as influenced by varying levels of vermicompost in acidic soils of Sikkim Himalayas, India

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ABSTRACT

A field experiment was conducted at Research Farm of ICAR Sikkim Centre, Tadong *rabi* 2011 and 2012 to find out the optimum dose of vermincompost for obtaining higher productivity, profitability and energetics of two local buckwheat cultivars in Sikkim Himalaya. Results revealed that among the two cultivars, Teethey recorded significantly higher number of grains/plant (170 and 165), test weight (23.8 and 23.2g), gross returns (60 × 10^3 and 54 × 10^3 ₹/ha), net returns (41 × 10^3 and 36 × 10^3 ₹/ha), B:C ratio (2.18 and 1.89), profitability (306 and 264 ₹/ha/day), production efficiency (7.88 and 7.09 kg/ha/day) and EUE (22.7 and 20.8%) over Meethey. This led to 10.8 and 9.4%, 17.2 and 18.4% and 11.7 and 8.4% increment in grain yield, B:C ratio and energy use efficiency (EUE) over Meethey. Application of vermicompost (VC) @ 2.5 tonnes/ha recorded higher values of grains/plant, test weight, grain yield and haulm yield resulting in highest gross returns. However, significantly higher B:C ratio (2.30 and 2.14) was found with VC @ 1.5 tonnes/ha over other VC levels during both years. Similarly, application of VC @ 1.5 tonnes/ha recorded maximum EUE (23.4 and 22.3%), energy productivity (1.34 and 1.28 kg/MJ) resulting in more energy saving for buckwheat production as compared to other levels of VC.

Key words: Buckwheat, Energetics, Net returns, Sikkim, Vermicompost

Buckwheat (*Fagopyrum* sp.) is most important life supporting and nutritious food grain crop of the tribes living in Sikkim Himalayas. It possesses tolerance ability against drought and extreme environments and has wide potential for adapting to climate change. Buckwheat is a short duration crop and fits well in double cropping systems under dry temperate conditions (Rana *et al.* 2002). Buckwheat having potential for fixing atmosphere nitrogen (Alekseyeva 2002), and thrives well under poor soil fertility conditions. Buckwheat may also play an important role in food supply as a contingent crop in aberrant weather situation due to crop failure. Meethey phapar (*Fagopyrum esculentum*) and Teethey phapar (*F. tataricum*) are the two major species cultivated in Sikkim Himalayas. Meethey phapar (*F. esculentum*) is grown at the lower altitudes, whereas Teethey phapar (*F. tataricum*) is grown at higher altitude due to its frost tolerance characteristic. In Sikkim, buckwheat is cultivated in about 4.46 thousand ha area and produces 4.16 thousand tonnes grains. However, the cultivation of buckwheat is declining sluggishly due to low productivity of buckwheat and change in land use pattern for high value vegetable crops. There are several reasons for low productivity of buckwheat in the region out of which proper nutrition is of paramount importance. Farmers of the state prefer local land races due to their palatability and adaptability, hence, grow them with minimal nutrients use. Energy is one of the most important indicators of crop performance. Energy productivity is decreasing with the escalating inputs cost without proportionate improvement in output of particular crops (Yadav *et al.* 2013a). Sufficient availability of the right energy and its effective and efficient use are prerequisites for improved agricultural production. Energy analysis, therefore, it is necessary for efficient management of scarce resources for improved agricultural production. There is ample scope for increasing production of buckwheat by good agronomic practices as well as proper fertility management. In organic production systems, supply of nutrients alone through FYM is not possible in general and hilly region in particular due to its limited availability in Indian (Yadav *et al.* 2013b). Therefore, present study was undertaken to find out the optimum dose of vermicompost for efficient buckwheat

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production for improving the nutritional security of local tribes of Sikkim Himalayas.

MATERIALS AND METHODS

A field experimentation was undertaken during *rabi* 2011 and 2012 at Research Farm of ICAR Research Complex for NEH Region, Sikkim Centre, Tadong (latitude 27°32' N, longitude 88°60' E, altitude 1 300 amsl). The soils of the experimental field was clay loam in texture and had soil pH 5.5, 215.3 kg/ha alkaline permanganate oxidizable N, 24.4 kg/ha Brays P_1, 198.7 kg 1 *N* ammonium acetate exchangeable K and 1.98% organic carbon using standard analytical procedures (Rana *et al.* 2014). The experiment was laid in Factorial Randomized Block Design (FRBD), assigning the local buckwheat cultivars (Meethey and Teethey) as factor 'A' and four levels of VC, viz. control, VC @ 1 tonne/ha, VC @ 1.5 tonnes/ha and VC @ 2.5 tonnes/ha as factor 'B'. All the treatments were replicated four times during both years.

Field was ploughed with bullock drawn plough followed by tilling with power tiller after the soil reached to tilth conditions and leveling was done with bullock drawn leveler. At the time of final ploughing/tilling VC was applied as per the treatments. Buckwheat (Meethey and Teethey) seed @ 35 kg/ha were placed at 3 to 5 cm deep with the spacing of 30 × 10 cm. Thinning was done at 15 days after sowing (DAS) to maintain optimum plant population. The crop was sown on 10 and 15 November in 2011 and 2012, respectively, as per the recommended practices and Meethey cultivar harvested on 6 and 10 March, although Teethey was harvested on 18 and 23 March during 2011 and 2012, respectively. Observations on yield attributes and yield were recorded as per the standard procedures. Cost of cultivation was computed based on the prevailing market prices of the inputs during the respective crop season. Net returns, B:C ratio, profitability and production-efficiency were computed by using the following relationship.

Net returns (₹/ha) = Gross returns (₹/ha) – cost of cultivation (₹/ha)

B: C = Net returns (₹/ha) / Cost of cultivation (₹/ha)

Profitability (₹/day) = Net returns (₹)/Crop period (days)

Production efficiency (kg/ha/day) = Grain yield of buckwheat (kg/ha)/crop period (days).

The various practices involved in crop production and yield of crops were converted into equivalent value of chemical energy (MJ or GJ/ha) for these conversions, standard values as given in Table 1 were used. Based on the energy equivalents of the inputs and output, energy use-efficiency (EUE), energy productivity, energy intensity in physical terms and energy intensity in economic terms were calculated.

EUE = Gross energy output (MJ/ha)/Energy input (MJ/ha)

Energy productivity (kg /MJ) = [Total output (grain + straw) (kg /ha)]/Total energy input (MJ /ha)

Table 1 Energy equivalents conversion factors for various inputs and outputs used in the study Energy equivalents conversion factors for various inputs and outputs used in the study

Particulars	Unit	Equivalent energy (MJ)	Remarks
Human labour	Man hour	1.96	Babu (2012)
Bullock	Pair hour	10.1	Panesar and Bhatnagar (1987)
Seed/Grain	kg	12.57	Computed based on energy produced from component
Haulm	kg	19.64	Beloborodko *et al.* 2013
Vermicompost	kg	1.20	Computed based on energy produced from component

Net energy output (MJ /ha) = Gross energy output (MJ/ha) – Energy input (MJ/ha)

Energy intensity in physical terms (MJ/kg) = Total energy input (MJ/ha)/Total output (grain + straw) (kg/ha)

Energy intensity in economic terms (MJ/₹) = Gross energy output (MJ/ha)/Cost of cultivation (₹/ha).

All the data obtained from buckwheat for consecutive two years was statistically analysed using the *F*- test following Gomez and Gomez (1984) at LSD values $P = 0.05$.

RESULTS AND DISCUSSION

Productivity

Critical appraisal of data in Table 2 reveals that Teethey recorded significantly ($P<0.05$) higher grains/plant (170 and 164), test weight (23.8 and 23.2), grain yield (1 064 and 958 kg/ha) and haulm yield (2 503 and 2 159 kg/ha) during both the years, respectively. Grain yield of Teethey was 10.8% and 9.4% higher over Meethey in 2011 and 2012, respectively. Application of vermicompost (VC) induced significant variation in yield attributes and yield of buckwheat. Among the levels, application of VC @ 2.5 tonnes/ha recorded significantly ($P<0.05$) higher number of grains/plant (203 and 198) and haulm yield (2 818 and 2 750 kg/ha) as compared to other levels. However, it remained statistically at par with vermicompost @ 1.5 tonnes/ha for the 1 000 grain weight and grain yield (1 289 and 1 126 kg/ha) during both the years. Improvements in growth and yield parameters of buckwheat due to organic manures and biofertilizers were also recorded by Tummaramatti *et al.* (2014). This augmentation in grain yield over the control may be attributed to favourable improvement in chemical and biological properties enhancing nutrients availability (Choudhary and Suri 2009). Increment in buckwheat yield at higher level of fertility especially nitrogen was also reported by Gunda *et al.* (2005). These results were corroborated with the findings of Glazova (2004) and Singh *et al.* (2015).

Table 2 Effect of vermicompost levels on yield attributes and yields of local buckwheat cultivars

Treatment	Grains/plant		1 000 grain weight (g)		Grain yield (kg/ha)		Haulm yield (kg/ha)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Local cultivars								
Meethey	160	151	22.4	22.0	960	876	2074	1986
Teethey	170	165	23.8	23.2	1064	958	2303	2159
SEm±	1.9	2.1	0.18	0.15	11	8	17	21
LSD (*P*=0.05)	5.8	6.3	0.56	0.44	34	25	51	64
Vermicompost (VC) levels								
Control	121	114	21.6	20.5	604	522	1190	1050
VC @ 1 t/ha	151	142	23.0	22.6	990	913	2117	1975
VC @1.5 t/ha	185	177	23.8	23.4	1164	1107	2628	2515
VC @ 2.5 t/ha	203	198	24.2	23.7	1289	1126	2818	2750
SEm±	2.7	3.0	0.26	0.25	16	12	24	30
LSD (*P*=0.05)	8.2	9.0	0.79	0.73	49	36	72	91

VC: Vermicompost.

Profitability

Data presented in Table 3 reveals that Teethey recorded 11 and 8% higher gross returns, 17 and 20% higher net returns, 17 and 14% higher B:C ratio, 10.8 and 21.7% higher production efficiency and 16.8 and 14.8% higher profitability as compared to Meethey during both years, respectively. This was due to higher grain and haulm yield, which fetches higher market prices. Application of VC caused marked variation in economics of buckwheat. Significantly ($P<0.05$) higher gross returns (73×10^3 ₹/ha and 65×10^3 ₹/ha) was recorded with the application of VC @ 2.5 tonnes/ha. However, significantly higher B:C ratio (2.30 and 2.14) was recorded with the application of VC @ 1.5 tonnes/ha in both years. With respect to net returns, production-efficiency and profitability, both the treatments (VC @ 1.5 tonnes/ha and 2.5 tonnes/ha) were remained statistically similar during both years. This may be due to the increased nutrient availability, which resulted in higher grain and haulm yield and due to lower cost of cultivation. Higher economic returns due to balance fertilization in buckwheat were also reported by Rana *et al.* (2005).

Energetics

Critical appraisal of data in Table 4 showed that Teethey recorded higher gross (58.66 and 54.44 GJ/ha) and net energy (55.99 and 51.83 GJ/ha) output, EUE (22.7 and 20.8%), energy productivity (1.31 and 1.19 kg/MJ) and energy intensity in economic terms (3.09 and 2.84 MJ/₹) as compared to Meethey during both years. This leads to 11.7 and 8.3% higher EUE as compared to Meethey in 2011 and 2012, respectively. This was due to higher biomass production of Teethey over Meethey. The output energy was determined by the amount and quality of harvestable biomass (Gelfand *et al.* 2010). In contrast, energy intensity in physical terms was higher in Meethey in both years. Application of VC @ 2.5 tonnes/ha recorded significantly

Table 3 Effect of vermicompost on economics of local buckwheat cultivars

Treatment	Gross returns ($\times 10^3$ ₹/ha)		Net returns ($\times 10^3$ ₹/ha)		B:C ratio		Production efficiency (kg/ha/day)		Profitability (₹/ha/day)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Local cultivars										
Meethey	54	50	35	31	1.86	1.63	7.11	6.49	262	229
Teethey	60	56	41	36	2.18	1.89	7.88	7.09	306	264
SEm±	0.6	0.4	0.6	0.6	0.03	0.02	0.08	0.06	4.3	3.1
LSD (*P*=0.05)	1.8	1.3	1.8	1.7	0.09	0.06	0.26	0.19	13.1	9.4
Vermicompost(VC) levels										
Control	34	29	21	17	1.69	1.33	4.48	3.87	157	124
VC @ 1 t/ha	56	52	38	34	2.18	1.94	7.33	6.76	284	252
VC @1.5 t/ha	66	63	46	43	2.30	2.14	8.62	8.20	341	317
VC @ 2.5 t/ha	73	65	48	40	1.91	1.58	9.55	8.34	355	293
SEm±	0.8	0.6	0.8	1.02	0.02	0.04	0.12	0.09	6.1	8.3
LSD (*P*=0.05)	2.5	1.8	2.5	3.09	0.07	0.13	0.36	0.26	18.5	25.07

VC: Vermicompost.

Table 4 Effect of vermicompost levels on energetics of local buckwheat cultivars

Treatment	Gross energy output (GJ/ha)		Net energy output (GJ/ha)		EUE(%)		Energy productivity (kg/MJ)		Energy intensity in physical terms (MJ/kg)		Energy intensity in economic terms (MJ/₹)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
Local cultivars												
Meethey	52.80	50.02	50.19	47.41	20.3	19.2	1.17	1.10	0.86	0.92	2.77	2.62
Teethey	58.60	54.44	55.99	51.83	22.7	20.8	1.31	1.19	0.77	0.85	3.09	2.84
SEm±	0.39	0.50	0.39	0.43	0.18	0.16	0.01	0.02	0.02	0.01	0.03	0.02
LSD (*P*=0.05)	1.18	1.51	1.18	1.30	0.53	0.49	0.03	0.05	0.05	0.02	0.08	0.07
Vermicompost (VC) levels												
Control	30.97	27.19	29.48	25.70	20.9	18.3	1.21	1.06	0.83	0.95	2.47	2.17
VC @ 1 t/ha	54.01	50.26	51.63	47.88	22.7	21.1	1.30	1.21	0.77	0.83	3.08	2.86
VC @1.5 t/ha	66.26	63.31	63.42	60.47	23.4	22.3	1.34	1.28	0.75	0.78	3.30	3.16
VC @ 2.5 t/ha	71.56	68.17	67.83	64.43	19.2	18.3	1.10	1.04	0.91	0.97	2.86	2.72
SEm±	0.55	0.71	0.55	0.61	0.20	0.23	0.01	0.02	0.02	0.01	0.04	0.03
LSD (*P*=0.05)	1.67	2.14	1.66	1.84	0.75	0.62	0.03	0.06	0.07	0.03	0.12	0.10

VC: Vermicompost.

higher gross energy output (71.56 and 68.17 MJ/ha) and net energy output (67.83 and 64.43 GJ/ha). Increase in energy output and net energy due to application of FYM was also reported by Deike *et al.* (2008). However, maximum EUE, energy productivity and energy intensity in economic terms was recorded with the application of VC @ 1.5 tonnes/ha in both years. This leads to about 22% increments in EUE and energy productivity and about 15% increment in energy intensity in economics terms over the VC@ 2.5 tonnes/ha. This was mainly due to lesser increase in seed and haulm yield of buckwheat at higher dose of VC, even though high energy input and capital for the production of unit amount of biomass was incurred as compared to VC @ 1.5 tonnes/ha.

From current study, it concluded that Teethey is more remunerative as compared to Meethey cultivar and application of vermicompost @ 1.5 tonnes/ha is the optimum dose of VC for producing higher yield and net returns with lower energy input in Sikkim Himalayas.

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