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Research Articles

Paper mill-based integrated nutrition of garden pea in the Eastern Himalayas

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ABSTRACT

Field experiment was conducted during *rabi* 2013-14 and 2014-15 to study the effect of paper mill waste integrated nutrition on yield, economics and soil health of garden pea varieties at ICAR-Research Complex for NEH Region, Nagaland Centre, Jharnapani, Nagaland. The experiment was laid out in split plot design and replicated thrice. Maximum seed yields (905 kg/ha), green pod yields (3454 kg/ha), gross return (₹ 108372/ha), net return (₹ 60260/ha) and B: C ratio (2.25) had recorded with Azad pea. Application of paper mill waste @ 1.0 t/ha gave higher yield attributes of garden pea than to its lowers levels. Highest gross return (₹ 109189/ha) and net return (₹ 57977/ha) was obtained with paper mill waste @ 1.0 t/ha, however the maximum B: C ratio (2.20) was noted in 0.5 t/ha. Significantly higher seed yield (926 kg/ha) and green pod yield (3449 kg/ha) were recorded with application of 100% RDF+25% RDF (ON), which was 53, 13, and 45% higher, respectively over control. Among integrated nutrition, maximum seed yield (977 kg/ha), green pod yield (3646), gross return (₹ 115328/ha), net return (₹ 64616/ha) and B:C ratio (2.28) was noted with 100% RDF + 25% RDF (ON). Soil health attributes, i.e. *p*H, EC, soil organic carbon; available NPK had improved significantly due to integrated nutrition. Thus, Azad pea could be grown with application of paper mill waste @ 1.0 t/ha along with 100% RDF+25% RDF(ON) for better productivity, profitability and soil health in Eastern Himalayas.

Keywords: Economics, Integrated nutrition, Paper mill waste, Pea varieties, Soil health

Garden pea (*Pisum sativum* var. *hortense*), one of the important *rabi* crops, is cultivated throughout the world for vegetable, pulse and processed and dehydrated forms (Kumar *et al*. 2014). India is the largest pea producing country in world with an area of 0.55 lakh ha and with an annual production of 5.45 lakh mt and commercially grown in Madhya Pradesh, Jharkhand, Himachal Pradesh, Punjab, Uttarakhand, Bihar, Haryana, Jammu and Kashmir, parts of Rajasthan and hilly parts of South India (Kumari *et al.* 2014, Anonymous 2017). *Jhum* cultivation is the most common form of agriculture in region (Kumar *et al*. 2019a) and several vegetables including beans and peas are grown in *Jhum* fields (Thirugnanavel *et al*. 2019). The prevailing climatic condition favors the cultivation of variety of crops in Northeast India (Deka *et al*. 2012). Recent past, cultivation of garden pea in Nagaland is gaining popularity. It fetches a high price in the market, thus economically remunerative. Although climatic conditions favour the cultivation, several biotic and abiotic factors hamper the cultivation of garden pea in Nagaland.

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Soil acidity adversely affects the growth, yield and quality due to toxicity of Al, Fe, Mn, low availability of N, P, K, Ca, Mg, S, Mo and microbial population in the affected soil (Kumawat *et al*. 2012). Soil amendments like dolomite, calcite, and lime to improve soil pH are generally not available in Northeast India (Kumar and Kumawat 2014). To cope-up these problems, paper mill waste (PMW), a waste product from paper mill industry could be used as an alternative. 448 tonnes/day of paper mill waste has been produced in Nagoan paper mill, Assam (Hazarika *et al*. 2007). It improves soil structure, water-holding capacity, reduces nutrient leaching, increases microbial biomass, increases the soil carbon and nitrogen, and makes P and S readily available (Ziadi *et al*. 2013). Further, it was proved that the paper mill waste increased the soil pH (Mohammadi *et al*. 2010). Hence, the present study was undertaken to evaluate the effect of paper mill waste-based integrated nutrition on productivity, profitability and soil health of garden pea under the Eastern Himalayas.

MATERIALS AND METHODS

Field experiment was conducted during *rabi* 2013-14 and 2014-15 at ICAR-Research Complex for North Eastern Hilly Region, Jharnapani, Medziphema, Nagaland, India (25°45′ N latitude, 93°53′ E longitude, 295 m altitude). Experimental soil (0-15 cm) was sandy loam (Inceptisol). Experiment was laid out in split-plot design and replicated thrice. Treatment comprised two garden

pea varieties (Arkel and Azad), three doses of paper mill waste (control, 0.5, and 1.0 t/ha) in main-plot and four levels of integrated nutrition [control (no fertilizers), 100% RDF (IN - inorganic), 75% (IN)+25% RDF (ON-organic) and 100% RDF (IN)+25% RDF(ON)] in sub-plots. The recommended doses of fertilizers (RDF: 20:50:40:20 kg NPKS/ha) and well-rotten farmyard manure (FYM) [to replace 25% of RDF (ON)] were applied as per treatments. The crops were planted during first fortnight of November using a row spacing of 30 cm during both the years. All the treatments were applied at the time of planting. Farmyard manures (FYM) was applied as per treatment on the basis of N content only. Crop was raised under limited irrigated condition with recommended package of practices. Data on all growth and yield attributes, *viz.* plant height, number of branches, dry matter, pods per plant and yields were recorded at maturity. Economics return was worked out by taking into account of incurred variables and treatment cost. All the inputs cost was summed up to work out total variable cost (TVC). Gross return (GR) was calculated by multiplying economic output by their corresponding market price. Finally, net returns (NR) was calculated by taking differences between GR and TVC (NR=GR−TVC) (Kumar *et al*. 2019b). Soil-chemical properties were analyzed for pH, EC, soil orhanic carbon (SOC), available N (Subbiah and Asija 1956), P (Olsen's *et al*. 1954) and K (Jackson 1999) before and at the end of the experiment. The initial analysis of soil showed that soil is acidic (*p*H 5.7), low in organic carbon (0.51%) and available nitrogen (216.3 kg/ha), moderate in phosphorous (10.5 kg/ha), and high in potassium (138.9 kg/ha). Since similar trend was noticed during both the years, the data pertaining to both the years were pooled and subjected to the statistical analysis (Gomez and Gomez 1984). Treatment comparisons were made using t-test at 5% level of significance.

RESULTS AND DISCUSSION

Effect of varieties: Pea varieties have significant impacts on growth characters and yield attributes which varied significantly (Table 1). Results indicated that maximum plant height (48.01 cm) and dry matter/plant (31.1 g) were recorded in Azad pea and significantly superior to Arkel. Among root attributes, nodules/plant (37.8), and root length (22.6 cm) had significantly higher in Azad pea. Growth characters varied among varieties, due to their inherent genetics, which could result in variation (Kumar *et al.* 2009). Maximum pods/plant (12.2), pod length (9.2 cm) and seeds/pod (7.5) were recorded by Azad, which was significantly superior to Arkel. Azad variety produced the highest seed yield (905 kg/ha), greed pod yield (3455 kg/ha) and straw yield (1537 kg/ha), which was 27.2, 9.5 and 21.9% higher when compared to Arkel. Kumar *et al*. (2014) also reported that differences in yield and straw yield among pea varieties. Greater availability of nutrients, especially at pod formation and development stages of more vigorous pea varieties, might have translocated the maximum of its reserved food material towards pod formation and development. Crop with higher growth rate produces higher yields as it has a maximum photosynthetic area for photosynthesis that could result in higher yield (Kumawat *et al*. 2015). Maximum gross return (₹ 108372/ha), net return (₹ 60260/ha) and B: C ratio (2.25) was found in Azad, while the minimum with Arkel. After crop harvest, soil chemical properties, i.e. *p*H, EC, SOC, available N,P,K, and yield attributes in plot of Azad pea were slightly higher than the plots of Arkel (Table 2). Kumar *et al.* (2014) also reported that the pea varieties did not influence soil health significantly.

Effect of paper mill waste (PMW): Application of PMW significantly increased growth and yield attributes of pea varieties. Maximum plant height (50.4 cm), dry matter/plant (33.3 g), nodules/plant (39.9), and root length (24.9 cm) were recorded with application of PMW @ 1.0 t/ha and significantly superior to rest of the levels. Pods/plant (12.4), pod length (9.4 cm) and seeds/pod (7.7) were found higher with PMW 1.0 t/ha, which was on a par with PMW @ 0.5 t/ha. Highest seed yield (926 kg/ha), green pod yield (3449 kg/ha) and straw yield (1597 kg/ha) were obtained with PMW @ 1.0 t/ha and found at par with 0.5 t/ha. An increase in grain (52.9%), green pod (12.8%) and straw yield (47.1%) were observed with PMW compared to control. In soybean, Gagaon and Ziadi (2012) observed that combined application of paper mill biosolid (30 Mg/ha) and wood ash resulted in highest grain yield. Anitha and Kumar (2017) reported that application of paper mill solid (30 t/ha) recorded the maximum seed yield (646 kg/ha), which was 355 kg/ha higher than control. Among PMW levels, highest gross return (₹ 109189/ha) and net return (₹ 57977/ha) had registered with 1.0 t/ha and significantly superior to control. While highest B: C ratio of 2.20 was obtained with PMW @ 0.5 t/ha closely followed by 1.0 t/ha. Analysis of soil revealed that application of PMW significantly improved soil health after harvest and chemical properties remain unchanged in control (Table 2). Soil *p*H, (6.13), SOC (0.6%), available N (225.7 kg/ha), P (12.9 kg/ha), and K (154 kg/ha) content were improved with 1.0 t PMW/ha, which was at par with 0.5 t/ha. Increase in soil pH might be due to release of H^+ ions, and organic acids during mineralization. Anitha and Kumar (2017) reported that application of paper mill solid @ 30 t/ha significantly reduced EC (16.1 dS/m) compared to control (30.04 dS/m). Similar finding was reported by Amini *et al.* (2012).

Effect of integrated nutrition: Among the levels of integrated nutrition, application of 100% RDF (IN)+25% RDF (ON) showed significant improvement in plant height, dry matter/plant, nodules/plant, and root length by 22.6, 27.3, 25.3, and 39%, respectively over 100% RDF (IN). Application of 100% RDF (IN) + 25 RDF (ON) increased pods/plant, pod length and seeds/pod by 29.9, 44.7 and 59.1%, respectively than that to 100% RDF (IN). Increase in growth and yield attributes might be due to better availability of water and nutrients through integrated nutrition, which improved soil health. The organic manures added along with inorganic fertilizers could have provided macro and micronutrients to the plants. Increase in seed, green pod and

Table 1 Effect of paper mill waste and integrated nutrition on growth and yield attributes of pea varieties (pooled data of 2 years)

Treatment	Plant height (cm)	Dry matter/ plant (g)	Nodules/ plant (no.)	Root length/ plant (cm)	Pods/plant (no.)	Pod length (cm)	Seeds/pod (no.)	Seed yield (kg/ha)	Green pod yield (kg/ha)	Straw yield (kg/ha)	Gross return (₹./ha)	Net return (₹./ha)	B:C ratio
Varieties													
Arkel	42.88	28.55	32.88	19.26	10.29	7.29	5.30	711.58	3156.33	1261.41	94113	44801	1.90
Azad pea	48.01	31.11	37.81	22.62	12.21	9.21	7.52	905.02	3454.84	1537.37	108372	60260	2.25
CD (P=0.05)	2.15	1.97	1.39	2.14	1.09	1.02	1.01	68.05	188.94	65.96	5233	5233	0.11
Paper mill waste (t/ha)													
Control	40.45	26.86	30.54	17.57	9.23	6.23	4.54	605.65	3058.24	1086.01	87563	41351	1.89
0.5	45.48	29.30	35.62	20.30	12.11	9.11	7.41	893.20	3409.11	1532.76	106976	58264	2.20
1.0	50.41	33.33	39.88	24.94	12.41	9.41	7.73	926.06	3449.39	1579.40	109189	57977	2.14
CD (P=0.05)	2.63	2.41	1.70	2.62	1.09	1.02	1.04	83.34	231.41	80.78	6409	6409	0.13
Integrated nutrition													
100% RDF	43.88	28.20	33.68	19.23	10.96	7.96	6.27	778.45	3216.32	1356.76	98178	52966	2.16
100% RDF (ON)	41.26	26.38	31.34	17.52	9.97	6.97	5.38	679.32	3008.93	1161.67	89675	39963	1.80
75% RDF + 25% RDF ON)	46.60	31.14	37.12	22.66	11.12	8.12	6.44	798.08	3350.77	1425.44	101789	52577	2.07
100% RDF (IN)+25% RDF(ON)	50.06	33.59	39.25	24.35	12.95	9.95	8.56	977.36	3646.30	1653.70	115328	64616	2.28
CD (P=0.05)	2.02	1.73	1.86	2.15	1.01	1.00	1.02	63.59	181.13	96.75	5167	5167	0.10

Table 2 Effect of paper mill waste and integrated nutrition on chemical properties of soil after crop harvest (pooled data of 2 years)

Treatment	pH	EC (dS/m)	Organic carbon (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
Varieties						
Arkel	5.80	0.20	0.57	220.05	11.40	147.60
Azad pea	5.94	0.20	0.58	222.23	13.01	148.99
CD (P=0.05)	NS	NS	NS	NS	NS	NS
Paper mill waste (t/ha)						
Control	5.53	0.23	0.53	213.78	11.47	141.72
0.5	5.95	0.20	0.59	223.97	12.27	149.19
1.0	6.13	0.17	0.60	225.66	12.88	153.99
CD (P=0.05)	0.33	0.03	0.03	6.44	1.07	5.48
Integrated nutrition						
100% RDF	5.65	0.21	0.54	214.47	11.13	142.85
100% RDF (ON)	5.90	0.21	0.57	221.31	12.21	149.60
75% RDF + 25% RDF (ON)	5.91	0.21	0.57	222.14	12.20	148.85
100% RDF (IN)+25% RDF(ON)	6.01	0.18	0.60	226.62	13.27	151.89
CD (P=0.05)	0.30	0.02	0.02	5.49	1.01	4.40

straw yield with 100% RDF (IN) + 25 RDF (ON) was 43.9, 22.2 and 42.4%, respectively compared to 100% RDF (IN). Increase in yield attributes and ultimately green pod yield may be due to beneficial effect of combined use of organic at a particular dose of inorganic fertilizers. Application of 100% RDF (IN) + 25% RDF (ON) gave the maximum gross return (₹ 115328/ha), net return (₹ 64616/ha) and B: C ratio (2.28) followed by 100% RDF (IN) (Table 1). Significantly enhanced *p*H (6.01), organic carbon (0.6%), available N (226.6 kg/ha) P (13.3 kg/ha) and K (151.9 kg/ha) were recorded with 100% RDF (IN) + 25% RDF (ON). Increase in soil organic carbon content might be due to decomposition of added organic manures to the soil (Kumar *et al.* 2014). Kumar *et al.* (2015) noted that the combined use of organic and inorganic fertilizers build available N status of soil, which might be due to mineralization. Increase in available P might be due to decomposition of organic matter and release of phenolic acids, which dissolves fixed P. There was significant buildup in potassium in treatments applied with 100% NPK fertilizer alone or in combination with different organics might be due to contribution of organics along with chemical fertilizers (Kumari *et al*. 2010, Kumari *et al.* 2012, Kumar *et al.* 2020). From the above findings, it may be concluded that to achieve optimum crop productivity, profitability and soil health, garden pea cv. variety Azad could be grown with application of paper mill waste @ 1.0 t/ha along with 100% RDF+25% RDF through farm yard manures in Eastern Himalayas.

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