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Agro-physical assessment of different pea (*Pisum sativum*) cultivars in lowland rice (*Oryza sativa*) fallow under no-till system for enhancing cropping intensity and productivity in mid hills of northeast India

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ABSTRACT

The cropping intensity of North Eastern Region (NER) of India is low (134%) mainly due to non-utilization of fallow lands after harvesting of rainy season rice (*Oryza sativa* L.). Pea (*Pisum sativum* L.) is one of the most potential leguminous field crops for crop diversification and enhancing productivity of rice based cropping systems in NER. Thus, a field experiment was conducted during 2012-13 and 2013-14 to evaluate the performance of pea cultivars under no-till (NT) condition after harvest of lowland rice in mid-hills (Umiam, Meghalaya, 950 m above sea level, 25°30'N latitude and 91°51'E longitude) of North East India.Twenty one pea cultivars were tested in rice fallow conditions under NT with the residual soil moisture. Out of 21 genotypes, 11 were pole type (PT) and 10 were dwarf type (DT). Among the cultivars, Arkel (95 days) followed by IPFD 4-6 (129 days) and IPFD 1-01 (130 days) were the most early maturing, and IPF 14 (150 days) and IPF 2-13 (150 days) were the most late maturing genotypes. Among all the cultivars, leaf area index, chlorophyll index, number of nodules/plant and nodule weight/plant were higher in Arkel among PT and IPFD 4-6 among DT cultivars. Among all PT cultivars, the higher seed yield, crude protein and total P content was recorded in Arkel (2.37 t/ha, 23.4% and 0.94%), VL-42 (2.33 t/ha, 23.2% and 0.91%) and MUD P 15 (2.29 t/ha, 22.3% and 0.84%); while among DT cultivars, these values were higher in IPFD 4-6 (2.25 t/ha, 20.7% and 0.75%), IPFD 1-01 (2.23 t/ha, 20.6% and 0.72%) and IPFD 99-13 (2.18 t/ha, 20.1% and 0.69%, respectively) than others. Aphid and rust were the most prominent insect and disease, respectively. Among PT cultivars, IPF 99-26 followed by MUD P 15 and among DT cultivars, Prakash and IPFD 5-10 showed maximum resistance against pea aphid. VL-42 was the most disease resistant variety followed by Arkel among the PT and Vikash followed by IPFD 99-13 among the DT cultivars. Thus, the study revealed the opportunity of pea cultivation in lowland rice fallow with suitable cultivars and appropriate technologies in mid-altitude of Meghalaya.

Key words: Crude protein, No-till, Pea, Percent disease index, Rice fallow, System productivity.

About 11.7 million ha of land in India is left fallow after rice (*Oryza sativa* L.) harvest (Ghosh *et al.* 2016), among which 82% areas of rice-fallow lies in the states like Asom, Bihar, Chhattisgarh, Jharkhand, Madhya Pradesh, Odisha, West Bengal and north eastern states (Pande *et al.* 2010). About 3.5 million ha area is under rice in NER, ~70% of which remains fallow during winter season. Pea (*Pisum sativum* L.), is a very potential crop for increasing farm income as well as cropping intensity (Das *et al.* 2014a). During the *rabi* season, due to excess moisture in valley lowlands owing to seepage from surrounding hillocks, land preparation is very difficult. Providing field drainage and adopting no-till (NT) in such situation may create favourable condition for pulses and can bring substantial area under pulse production. Thus, introduction of pea in rice fallows with appropriate production technologies may increase cropping intensity, improve soil health, and productivity in fragile NER of the country.

Pea is a leguminous crop, belongs to family leguminoseae, and contains high amount of protein having essential amino acids particularly lysine. Peas are very common nutritious vegetable and pulse and are mainly cultivated as winter crop throughout the world. Pea is the most important pulse crop mainly grown on residual soil moisture and prominent source of vegetable protein (Singh *et al.* 2011). Besides fixing atmospheric nitrogen (N) and

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benefitting the succeeding crop with residual N in soil, pea is also adapted to local climatic and soil fertility conditions (Das *et al.* 2014a). Cultivation of crops under NT with adequate residue retention is a cost effective –conservation practice that saves time, facilitate early sowing, conserves soil moisture, reduces energy requirement and minimizes cost of cultivation (Das *et al.* 2014b). NT provides better ecosystem to crop than that of conventional tillage (Lal 2013). Higher yield of pulse after wet season (*kharif*) rice with reduced tillage (RT) than CT has been reported (Gangwar *et al.* 2006). RT with crop residue management is found to reduce soil water evaporation, soil sealing and crusting. The suitability of NT is dependent on number of factors like soil-climatic conditions, weed control level, residue management and cultural practices. If crop residues are retained on the soil surface in combination with suitable planting techniques, it may alleviate terminal drought condition in pulses by conserving soil moisture and bring overall improvement in resource management.

Despite large number of cultivars, pea yield per unit area in India is low due to many factors like poor cultural practices; weed, insect and disease problems, etc. Aphids, leaf miner, white rust, stem rot etc. are some of the important insect pests of pea. Thus, host plant resistant selection is one of the best options to overcome these problems. The crop has great potential in the NER, especially in rice fallow and attempt should be made to improve yield through the development and/or identification of high yielding varieties which are adaptable to local climatic conditions. The present investigation was conducted to identify suitable genotypes of peas for cultivation in rice fallow for enhancing cropping intensity and productivity of rice based systems at mid altitude subtropical agro-climatic conditions of Meghalaya.

MATERIALS AND METHODS

Field experiments under rainfed conditions were conducted during winter season for two consecutive years (2012-13 and 2013-14), in the lowland field at Agronomy farm, Indian Council of Agricultural Research (ICAR) Research Complex for North Eastern Hill (NEH) Region, Umiam, Meghalaya, India. The experimental site was a valley lowland (950 m a.s.l., 25°30'N latitude and 91°51'E longitude) surrounded by hillocks. The experimental field was under rice cultivation (monocropping) for more than two decades.

The experimental site (Umiam) is characterized by a subtropical climate. The area receives a good amount of rainfall (2450 mm annually) most of which is concentrated in rainy season starting from May and extended up to the month of October. However, the amount of rain received during November to March is very less. Daily mean temperature during the monsoon season (June to October) ranges from 23 – 32^{0}C. The year 2012 and 2013 received less amount of rainfall (2089.4.1 mm and 2021.8 mm, respectively) than the average annual rainfall (2450 mm) of the site. The soil of the experimental site is a *Typic Paleudalf*, clay loam in nature, acidic in reaction (pH 5.3), low in available nitrogen (N) (253.7 kg/ha) and phosphorous (P) (11.2 kg/ha) and medium in available potassium (K) (259.9 kg/ha).

The experiment consisted of 21 cultivars of pea collected from multiple sources like Indian Institute of Pulse Research (IIPR), Kanpur; ICAR Research Complex for NEH Region, Tripura Centre and Plant Breeding Section, ICAR Research Complex for NEH region, Umiam etc. Eleven pole type (PT) cultivars (IPF 1-22, IPF 5-19, IPF 99-26, IPF 14, IPF 99-25, IPF 2-13, MUD P-15, VL-42 (Tall), TRC 8, TRC 9 and Arkel) and ten dwarf type (DT) cultivars (IPFD 4-6, IPFD 1-01, IPFD 99-13, IPFD 5-10, IPFD 5-01, IPFD 2-5, IPFD 3-7, IPFD 5-3, Prakash and Vikash) were evaluated under NT in rice fallow conditions. The 21 cultivars were tested in Randomized Block Design (RBD) and replicated thrice. The gross plot size was 5.0 m × 4.0 m.

Rice variety Shahsarang-1 was transplanted at a spacing of 20 cm × 20 cm using adequate fertilizer (80:60:40 kg N, P_2O_5 and K_2O/ha) and farmyard manure (FYM) 5 t/ha during first week of July. One weeding at 35 days after transplanting (DAT) was done using a manually drawn cono-weeder and two hand weeding (HW) at 25 and 50 DAT were performed for managing weeds in rice. Pest and diseases were managed chemically as and when required. The rice fields were drained at physiological maturity (one week before harvesting) to get a suitable soil condition to cultivate the succeeding *rabi* crop pea. The harvesting of the rainy season (*kharif*) rice was done manually by leaving about 20 cm standing stubbles in the field by the end of November. After harvesting of rice, pea was sown under NT system in first fortnight of December. Pea was sown by opening a narrow furrow (V shaped slot) in between two rows of rice using a manual furrow opener. A recommended dose of 30 kg N, 60 kg P_2O_5 and 40 kg K_2O/ha were applied in furrows before sowing of pea seeds and covered the seed with soil and FYM mixture (2:1 ratio) to give a good seed-soil contact. Spacing of 20 cm × 8-10 cm was maintained for pea. The *rabi* crop of pea was raised with residual soil moisture and one life saving irrigation at flowering stage was provided for better pod development and yield.

The growth (plant height, primary and secondary branches), yield attributes (pods/plant and seeds/pod) and yield of pea (seed and stover) were recorded at harvest. For studying nodulation, five plants were selected randomly 60 days after sowing (DAS) from the rows marked for sampling from each plot. Nodules separated from the roots and number of nodules were counted from each plant and expressed as number of nodules/plant. The nodules separated from the roots were initially dried under the sun and oven dried at 70°C for complete drying. The dry weight was recorded when samples attained a constant weight. The nodule weight was expressed as mg/plant.

Crop growth rate (CGR) was computed by using formula of Watson (1952) and expressed as g/m^2/day.

$$CGR = \frac{W_2 - W_1}{T_2 - T_1} \text{ g/m}^2\text{/day}$$

where, W_1 and W_2 are the dry weights at times T_1 and T_2,

respectively. The CGR was worked out for the duration between 0-30, 30-60 and 60-90 DAS.

Length and width of the top, middle and bottom leaves of each plant were measured for calculating average leaf area. Primary branches, secondary branches, leaves, roots were separated, dried and weighed and recorded as per plant basis. Yield of pea was estimated from weight of sun dried seeds obtained from each net plot area after threshing and cleaning at 12% moisture content. The rice- equivalent yield (REY) yield of pea (obtained by multiplying market price of pea with pea seed yield and dividing it with market price of rice) was added to rainy season rice yield (4.25±0.27 t/ha) to obtain REY of the rice-pea system (data not presented).

The total N content in pea seed was determined by modified micro-Kjeldhal Method (Subbiah and Asija 1956). Crude protein content in pea seed (%) was obtained by multiplying the total nitrogen content with 6.25. The total P content of the samples was estimated by the Vanadomolydophosphoric Yellow Colour method (Bray and Kurtz 1945).

Infestation of each pea genotype by aphid was assessed by recording the numbers of plants in which shoots were damaged by the presence of aphid. Damage was assessed visually, as the attack by the nymphs and adult produces a yellowish colour and wilting symptoms that is easily recognizable with the naked eye. At each sampling event, the infestation rate per genotype was calculated.

$$\text{\% Insect infestation} = \frac{\text{Number of infested plant of a given genotype}}{\text{Total number of plants of that genotype}} \times 100$$

Finally, the influence of plant age on aphid infestation was tested separately for each genotype by determining the linear correlation between plant age and the infestation rate of each genotype. The Percent Disease Incidence (PDI %) for pea rust (*Uromyces fabea*) was calculated as per the procedure of Akhtar *et al.* (2010). To compute PDI, individual symptomatic plant ratings for each genotype were summed up and divided by the number of infected plants. This method of calculating disease incidence has been used in the tea plant for blister blight, in chilies for fruit rot, powdery mildew and in citrus for citrus canker (Anand *et al.* 2010)

$$\text{PDI (\%)} = \frac{\text{Sum of all disease ratings of the selected plants}}{\text{Total no. of plants assessed}} \times 100$$

The experimental data pertaining to each parameter of study were subjected to statistical analysis by using the technique of analysis of variance and their significance was tested by "F" test (Gomez and Gomez 1984). Standard error of means (SEm±) and least significant difference (LSD) at 5% probability (P=0.05) were worked out for each parameter studied to evaluate differences between treatment means.

RESULTS AND DISCUSSION

Morphological description

In present study, typical plant structure and colour was observed in different cultivars like IPF 1-22, IPF 5-19 and MUD P 15 had more tendrils compared to other PT cultivars but colour differences were observed between these lines. IPF 1-22 had pale green leaf and IPF 5-19 and MUD P 15 had green and both of these lines had less leaves per plant. But in IPF 99-26, IPF 14, IPFG 99-25, IPF 2-13, VL 42, TRC P 8, TRC P 9 and Arkel had less tendril and more leaves and leaf colour was dark green. Dwarf cultivars IPFD 4-6, IPFD 1-01, IPFD 2-5, IPFD 3-7 and IPFD 5-3 had more no of tendril, less leaves and green leaf but IPFD 99-13, IPFD 5-10, IPFD 5-01, Prakash and Vikash had less tendril, more leaves and leaves were dark green in colour. Among all the cultivars, Arkel (as it is a garden pea) had wrinkle seed with green colour and other had round with yellow colour.

Crop ontogeny

Pea cultivars were sown on last week of November. PT cultivars took 4-6 days and DT cultivars took 4-5 days for germination (Table 1). Among all PT cultivars, Arkel (45 days) was the earliest to flower initiation followed by VL 42 and MUD P 15 while IPF 2-13 (78 days) followed by IPF 99-25 took maximum days for flower initiation. Among all DT cultivars, IPFD 4-6 (65 days) followed by IPFD 1-01 and IPFD 99-13 (D) took less days for flower initiation. The 50% flowering took about 54 to 84 days for different PT cultivars and 71-79 days for DT cultivars. Among all cultivars, Arkel took least days for 50% flowering followed by VL 42. Among PT cultivars, IPFD 1-01, IPFD 99-13 and IPFD 4-6 have taken least days for 50% flowering. Among PT cultivars, Arkel took the least days for 100% flowering, while among DT cultivars, IPFD 4-6 took least days for 100% flowering. Arkel was the earliest to mature (95 days) followed by VL 42 while the maximum days to maturity was taken by IPF 14 (150 days). Among all DT cultivars, IPFD 4-6 (129 days) was the earliest to mature followed by IPFD 1-01 (Table 1). The possible characters of early flowering in certain genotypes (Arkel, VL-42 and MUD P 150 PT cultivars and IPFD 4-6, IPFD 1-01 and IPFD 99-13) indicated adaptability of these genotypes, better and efficient utilization of nutrients in a relatively harsh environment which might have resulted in early termination of vegetative phase and initiation of reproductive stage as compared to genotypes which took longer time to flower. The heat unit requirement for flowering is an important factor for plant to flower early or late (Ishtiaq *et al.* 1996). More time to flowering in some genotypes with more number of branches is an indication of more vegetative growth due to favourable climatic condition. It was observed that some genotypes had determinate type growth and their plant bloomed and exhausted simultaneously, hence these had less branches per plant as have been observed by Hussain *et al.* (2002). In germplasm collected from different climatic conditions, rate of acclimatization may be considered the possible cause of variation (Hatam *et al.* 2001). Moreover, this variation could be due to genetic variability of different germplasm.

Table 1 Ontogeny, plant height and number of branches of pea cultivars under no-till condition in rice fallow (two years pooled data)

Variety	Days to emergence	Days to flower initiation	Days to 50% flowering	Days to 100% flowering	Days to pod formation	Days to mature	Plant height at harvest (cm)	No of primary branches/plant at harvest	No of secondary branches/plant at harvest
IPF 1-22	4	68	77	87	94	142	115.7	8.8	8.5
IPF 5-19	5	75	84	97	103	148	126.8	8.9	10.2
IPF 99-26	4	71	85	96	104	145	135.6	9.6	9.2
IPF 14	6	74	83	98	106	150	132.3	9.9	10.3
IPF 99-25	4	75	84	93	103	147	132.4	8.4	10.8
IPF 2-13	5	76	84	93	107	150	122.7	9.0	10.8
MUD P-15	5	63	70	85	95	135	112.5	9.8	11.2
VL-42	4	58	68	89	99	131	139.5	9.9	10.5
TRC P 8	5	62	71	88	102	146	119.3	8.0	10.3
TRC P 9	5	67	75	88	101	138	118.2	8.4	10.5
Arkel	4	45	52	60	68	95	120.5	8.2	10.65
IPFD 4-6	4	63	73	80	89	129	83.2	4.8	7.6
IPFD 1-01	4	65	71	79	89	130	81.9	4.7	5.8
IPFD 99-13	5	66	71	81	90	131	78.8	4.8	6.8
IPFD 5-10	4	66	74	83	94	131	82.4	5.0	6.3
IPFD 5-01	5	65	72	80	92	135	82.8	4.7	6.2
IPFD 2-5	4	66	73	83	94	134	85.4	4.5	6.7
IPFD 3-7	4	61	70	78	87	138	83.4	4.9	6.7
IPFD 5-3	4	69	78	87	99	140	78.87	5.8	6.9
Prakash	4	69	79	90	105	142	79.8	5.5	5.82
Vikash	4	62	70	81	95	132	82.1	5.4	5.80
SEm±							4.80	0.31	0.43
CD (P=0.05)							13.71	0.90	1.24

Growth and physiological attributes

The tallest plants were observed in VL-42 (139.5 cm) followed by IPF 99-26, IPF 99-25 and IPF 14 among PT cultivars and IPFD 2-5 (85.4 cm) had tallest plants followed by IPFD 3-7, IPFD 4-6 and IPFD 5-01 among DT cultivars. Significantly the shortest plants were observed in MUD P-15 followed by IPF 1-22 among PT and IPFD 99-13 followed by Prakash and IPFD 1-01 among DT cultivars. The highest numbers of primary branches/plant were recorded with VL 42 followed by IPF 14 and MUD P 15 while the lowest number of primary branches/plant were recorded with Arkel followed by IPF 99-25 among PT cultivars. The highest number of primary branches among DT cultivars were observed in IPFD 5-3 followed by Prakash and Vikash while the lowest primary branches/plant were observed in IPFD 2-5 followed by IPFD 5-01. Secondary branches/plant were highest in VL 42 followed by MUD P 15, IPF 99-25 and IPF 2-13, while the lowest number of secondary branches/plant were observed in IPF 1-22 followed by IPF 99-26 and IPF 5-19. The maximum number of secondary branches were observed in IPFD 4-6 followed by IPFD 5-3 and IPFD 99-13 and the lowest were observed in Vikash followed by IPFD 1-01 and Prakash (Table 1). Considering plant biomass, VL 42 followed by IPF 2-13 and IPF 99-25 had the higher dry matter production (DMP) and the lowest was observed in IPF 1-22 followed by IPF 99-26 than other cultivars among PT cultivars. Whereas, among the DT cultivars, the highest DMP was observed in IPFD 3-7 followed by IPFD 5-01. The lowest biomass/plant were observed in IPFD 5-3 followed by IPFD 2-5 and IPFD 4-6 (Table 2). Different responses to plant height might be due to genetic characteristic of genotypes and adaptability to a particular environment. Since the genotypes Arkel, VL 42 and MUD P 15 and IPFD 4-6, IPFD 1-01 and IPFD 99-13 were earlier in flowering; these cultivars had less time for attaining vegetative growth, reserved food materials diverted to sex expression, resulting in dwarfishness. The dwarf plant which could not benefit from prevailing climatic condition showed less adaptability in tested area (Ishtiaq *et al.* 1996). Crop Growth Rate (CGR) was higher in PT than DT cultivars (Table 2). The CGR was higher at 60 DAS than 30 DAS and thereafter it decreased at 90 DAS. The

Table 2 Growth and physiological parameters of different pea cultivars (two years pooled data)

Variety	Plant dry matter at harvest (g/plant)	Crop Growth Rate (g/m^2/day)			Leaf area index at 60 DAS	Chlorophyll index at 60 DAS	No of nodules/ plant at 60 DAS	Nodule weight (mg/plant) at 60 DAS
		0-30 DAS	30-60 DAS	60-90 DAS				
IPF 1-22	14.6	5.23	6.20	6.22	3.13	46.4	55.7	730
IPF 5-19	14.7	5.43	6.11	6.32	2.84	42.51	52.3	720
IPF 99-26	14.6	5.41	6.11	6.20	3.28	51.0	59.1	832
IPF 14	14.7	5.50	5.72	6.00	2.64	41.2	51.2	656
IPF 99-25	15.1	5.71	6.21	5.70	2.94	58.4	51.2	740
IPF 2-13	15.2	5.81	6.13	5.84	3.03	44.1	54.8	724
MUD P-15	14.9	5.10	6.16	6.15	4.37	48.0	51.0	736
VL-42	15.3	5.83	6.31	6.55	5.08	58.4	53.1	750
TRC P 8	14.8	5.34	5.98	6.08	3.45	46.0	49.6	698
TRC P 9	14.8	5.54	5.70	6.06	3.27	47.1	50.7	724
Arkel	14.7	5.19	6.00	6.40	4.51	60.7	54.8	774
IPFD 4-6	12.4	4.65	4.89	4.87	2.95	46.00	54.4	792
IPFD 1-01	12.5	4.56	4.90	5.18	2.86	42.3	52.4	736
IPFD 99-13	12.6	4.67	5.01	5.05	2.63	39.4	48.7	704
IPFD 5-10	12.5	4.58	4.93	5.10	2.58	36.5	46.8	696
IPFD 5-01	12.7	4.65	4.94	5.19	2.38	31.0	38.9	710
IPFD 2-5	12.3	4.59	5.07	4.71	2.15	35.2	41.9	710
IPFD 3-7	12.7	4.70	4.86	5.71	2.33	38.0	42.6	670
IPFD 5-3	12.3	4.51	5.13	5.25	2.41	40.3	44.9	744
Prakash	12.6	4.99	4.56	5.11	2.14	38.1	49.4	694
Vikash	12.5	4.73	4.79	4.93	2.46	49.0	49.4	696
SEm±	0.36	0.25	0.31	0.27	0.16	2.24	0.94	16
CD (P=0.05)	1.03	0.72	0.90	0.78	0.46	6.39	2.70	46

DAS, days after sowing

higher CGR was observed in VL 42, MUD P 15 and Arkel among PT cultivars. Lower CGR was observed in IPF 5-19, TRC P 8 and IPF 14 than others. Among all DT cultivars, CGR at 90 DAS was higher in IPFD 1-01 followed by IPFD 5-10, IPFD 4-6 and IPFD 99-13 while the lowest in Vikash and Prakash than others. Among all PT cultivars, LAI, chlorophyll index, number of nodules/plant and nodule weight/plant was higher in cultivar Arkel followed by VL-42 and MUD P 15 than others. Among all DT cultivars, LAI, chlorophyll index, nodules/plant and nodule weight was higher in IPFD 4-6 followed by IPFD 1-01 and IPFD 99-13 as compared to rest of the cultivars (Table 2)**.**

Yield attributes and yield

Among PT cultivars, the maximum number of pods/ plant was recorded with Arkel (35.61) followed by MUD P 15 and VL 42, while the lowest number of pods/plant was recorded with IPF 14 (22.84) followed by IPF 5-19 (Table 3). Among DT cultivars, IPFD 4-6 (38.98) had the highest pod/plant followed by IPFD 1-01 and IPFD 99-13 while the lowest number of pods/plant was recorded with IPFD 3-7 (32.13) followed by Prakash. More number of pods per plant may be due to small pod size as less nutrient are required for small pods compared with larger pods (Qasim *et al.* 2001). Number of seeds/pod was relatively higher in PT cultivars and the highest seeds/pod was recorded in Arkel followed by VL-42 and the lowest in IPF 14. Among DT cultivars, IPFD 4-6 had the highest seeds/ pod followed by IPFD 1-01 while lowest was observed in Prakash followed by IPFD 3-7. The seed index (weight of 100 seed) was highest in VL-42 followed by Arkel. The lowest seed index was recorded in IPF 5-19 followed by IPL-318. Among DT cultivars, the maximum seed index was observed in IPFD 4-6 followed by IPFD 1-01 while the lowest was observed in IPFD 2.5 followed by IPFD 5-3. Greater availability of nutrients especially during pod formation and development stages of more vigorous pea varieties might have translocated maximum of its reserved food material towards seed formation and development (Ishtiaq *et al.* 1996, Arshad *et al.* 1998).

Among PT cultivars, the highest seed yield was recorded in Arkel (2.37 t/ha) followed by VL-42 and MUD P 15 (Table 3). Whereas, among DT cultivars, IPFD 4-6 (2.25 t/ha) recorded the highest yield followed by IPFD 1-0 and

Table 3 Yield attributes, yield and quality parameters of pea cultivars in rice fallow (two years pooled data).

Variety	No of pods/ plant	No of seeds/ pod	Seed yield (t/ha)	Biomass yield (t/ha)	Seed index (g/100 seed)	Crude protein (%)	Total P (%)	Aphid infestation (%)	Rust infestation (%)
IPF 1-22	28.7	6.14	2.23	8.85	24.8	20.2	0.77	2.10	5.25
IPF 5-19	23.9	5.52	2.03	8.16	22.8	17.4	0.63	3.93	10.98
IPF 99-26	27.3	5.81	2.14	8.67	24.2	19.2	0.71	0.45	3.47
IPF 14	22.8	5.37	1.98	7.92	21.3	18.0	0.62	1.79	8.01
IPF 99-25	28.0	5.91	2.18	8.79	25.4	20.1	0.75	3.03	5.27
IPF 2-13	27.5	5.63	2.05	8.37	23.7	18.2	0.65	0.63	6.41
MUD P-15	33.0	6.39	2.29	9.01	25.3	22.3	0.84	2.90	6.26
VL-42	32.6	6.52	2.33	9.13	25.9	23.2	0.91	0.79	0.19
TRC P 8	27.9	5.74	2.10	8.54	24.0	18.9	0.68	1.52	6.01
TRC P 9	30.8	6.19	2.27	8.97	25.0	21.9	0.81	2.63	8.30
Arkel	35.6	6.57	2.37	9.24	26.3	23.4	0.94	1.79	1.57
IPFD 4-6	39.0	5.68	2.25	6.68	25.9	20.7	0.75	3.69	6.90
IPFD 1-01	38.7	5.45	2.23	6.58	25.4	20.6	0.72	2.37	14.69
IPFD 99-13	36.7	5.28	2.18	6.54	25.0	20.1	0.69	1.37	3.91
IPFD 5-10	36.0	5.09	2.11	6.51	24.7	19.6	0.66	0.48	9.80
IPFD 5-01	34.4	4.51	1.94	6.23	24.1	16.7	0.57	0.93	5.98
IPFD 2-5	34.7	4.67	2.02	6.34	23.2	19.1	0.61	3.46	6.00
IPFD 3-7	32.1	4.05	1.84	5.94	23.5	18.3	0.50	7.87	5.67
IPFD 5-3	33.0	4.19	1.88	6.18	23.8	18.8	0.53	9.04	10.93
Prakash	33.0	3.87	1.73	5.75	23.2	17.9	0.57	0.35	8.27
Vikash	35.7	4.81	2.08	6.48	24.3	19.4	0.63	1.54	3.46
SEm±	0.30	0.12	0.05	0.07	0.23	0.97	0.03	0.48	0.97
CD(*P*=0.05)	0.85	0.33	0.14	0.21	0.67	2.76	0.10	1.38	2.77

IPFD 99-13. Higher yield potential of PT cultivars such as Arkel, VL-42 and MUD P 15 and DT cultivars such as IPFD 4-6, IPFD 1-01 and IPFD 99-13 has been reported by other researchers (Singh *et al.* 2012). This may be mainly due to better growth and their positive influence on the yield parameters than other cultivars. Plant height, plant biomass, branches/plant, days to maturity, etc. has significant positive contributions towards grain yield (Singh *et al.* 1989). The greater number of pods/plant, seeds/pod and seed index in pea resulted in higher seed yield in these cultivars. Among all PT cultivars, the higher biological yield was recorded in Arkel followed by VL-42 and MUD P 15. Among DT cultivars, IPFD 4-6 followed by IPFD 1-01 and IPFD 99-13 had the highest biological yield.

Among PT cultivars, the higher REY was recorded with rice –Arkel (8.99 t/ha) system followed by VL-42 (8.91 t/ha) and MUD P 15 (8.83 t/ha); while rice –IPF 14 (8.21 t/ha) followed by IPF 5-19 (8.31 t/ha) system had the lower REY than other systems. Among DT cultivars, rice – IPFD 4-6 (8.75 t/ha) followed by IPFD 1-01 (8.71 t/ha) and IPFD 99-13 (8.47 t/ha) had the higher REY and Prakash (7.71t/ha), IPFD 3-7 (7.93 t/ha) had lower REY, than others. High rice equivalent yield and system productivity due to inclusion of pulses such as pea and lentil after rice has been also reported by Das *et al.* (2014b).

Crude protein and total P in pea seeds

Among all PT cultivars, crude protein and total P content was the highest in Arkel followed by VL-42 while the lowest crude protein and total P was observed in IPF 14 followed by IPF 5-19 (Table 3). Among all DT cultivars, the highest crude protein and total P was observed in IPFD 4-6 followed by IPFD 1-01 while lowest was recorded in IPFD 5.01 (D) followed by IPFD 2-5.

Insect pest and disease attack

The major infestation among insects were pea aphid (*Acyrthosiphon pisum* Harris) followed by pea leaf minor (*Phytomyza affinis*) and pea pod borer (*Etiella zinckenella* Tr.). Pea leaf minor infestation was observed in very early growth stage though the severity was very less. Pea aphids were observed in early growth stage to fruiting stage but severity of infestation was more in flowering stage. Pea pod borer infestation was observed in early fruiting stage to late

fruiting stage. Among all PT cultivars, the maximum pea aphid infestation was observed in IPF 5-19 (3.93%) followed by IPF 99-25 (3.03%); while less infestation was noticed in IPF 99-26 (0.45%) followed by MUD P 15 (0.79%) (Table 3). Among all DT cultivars, the maximum pea aphid infestation was observed in IPFD 5-3 (9.04%) followed by IPFD 3-7 (7.78%) while less infestation was observed in Prakash (0.35%) followed by IPFD 5-10 (0.48%)

Pea rust (*Uromyces pisi)* was most dominant disease followed by powdery mildew (*Erysiphe polygoni*) and stem rot (*Rhizoctonia solani)*. Stem rot and powdery mildew infested during early growth stage to fruiting stage but pea rust appeared in fruiting stage. The maximum pea rust infestation was recorded in IPF 5-19 (10.98%) followed by TRC P 9 and IPF 14 while least infestation was observed in VL 42 (0.19%) followed by Arkel among the PT cultivars, while among DT cultivars, the maximum pea rust infestation was observed in IPFD 1-01 (14.69%) followed by IPFD 5-3 while least infestation was observed in Vikash (3.46%) followed by IPFD 99-13.

From the present study, it can be concluded that there is enough scope for cultivation of pea in lowland rice fallows under NT system in the mid-hills of NER of India. Cultivars like Arkel, VL-42 and MUD P 15 among PT and IPFD 4-6, and IPFD 99-13 among DT are the most promising in terms of growth, resistance to pest and diseases and productivity. However, more cultivars from different institutes should be evaluated to identify short duration and high yielding varieties suitable for the region.

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