



Agro-techniques for productivity enhancement in pea (*Pisum sativum*) at eastern Himalayan region

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ABSTRACT

Small scale experiments on pea (*Pisum sativum* L.) were designed during 2008 to 2011 at ICAR Research Complex for NEH Region, Basar, Arunachal Pradesh. The main objective of the study was to develop a suitable package of practices for the region to utilize the fallow land during post rainy season. Results confirmed that the minimum tillage registered 29.4% higher pod yield, while conventional tillage improved the length and dry biomass of root over no tillage. The seeds sown on 15 October registered 8.8-19.4% higher yields than the before and later sowing dates, but, line sown crop has obtained 18.2% higher pod yield over broadcasting. Planting geometry with 30 cm × 10 cm registered 5.4-21.4% higher pod yield. Phosphorus application at 75 kg/ha registered yield improvement of 2-32.3% and better utilization of irrigation water at 30 and 60 days after sowing (DAS) improved by 28.5% higher yield, in contrary, water use efficiency was improved by 9.7-15.3% with no irrigation. Hand weeding twice at 25 and 50 DAS recorded 9.5-39.6% higher yield over no weeding. Adoption of better package of practices in newer area under existing cropping system will play a key role in further yield improvement. Therefore, as per the availability of resources at site and feasibility, growers may use the practices to obtain higher pod yield in the region.

Key words: Agro-techniques, Pea, Phosphorus, Planting geometry, Water, Weed management

Despite the ever increasing demands for food, vast area is left fallow after cultivation of rainfed rice and maize in the eastern Himalayan region (EHR) of India (Choudhary *et al.* 2013). In EHR, the population growth rate is quite high and available cultivable land area is limited. This is pressurizing the farmers to produce more food from the available arable land. Though, the EHR is bestowed with bountiful rainfall, favourable climate, fertile soil and abundant natural resources to take more than one crop successively in a year, however, most of the area has been kept fallow. After harvesting of *kharif* crop, there is plenty of soil moisture, along with subsequent rainfall, to support the following crop (Saha and Ghosh 2010). After harvesting rice and/or maize by early October, entire upland, wet and terrace lands can be potentially utilized for growing sequential crop. In the region, the farm land is fragmented and topography is undulated, thus, use of machinery and evolved technologies are difficult. Similarly, marginal and small farmers in the region have limited irrigation facilities

and are profoundly subsistence farmers. Wetland and terrace land have sufficient soil moisture and water sources, those can be diverted and judiciously utilized. In such land, leguminous crops may accommodate to improve the soil fertility and that would also complement protein requirements of the locality.

Legume crops emerge early with faster development over the cereals and have smothering effect, which reduce the soil erosion and suppress the weed density. Similarly, incorporation of residues in the field improves the nutrient availability by nutrient cycling, better utilization of resources and reduction in leaching loss (Xu *et al.* 2010). Legumes can also be grown not only to provide the additional yield but also to improve the nutritional security, livelihood and land use efficiency. Agricultural productivity largely depends on use of quality seeds. This is multifaceted and influenced by many factors, of which, maintaining optimum plant populations is an important factor that contributes to higher yield with least cost involvement and is a vital agronomic factor. Hence, the present investigation was undertaken to identify the best agronomical management practices for improved pea (*Pisum sativum* L.) yield in the EHR region.

MATERIALS AND METHODS

A field experiments was carried out in silty loam soil during 2008, 2009, 2010 and 2011 at the experimental farm

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of ICAR Research Complex for North Eastern Hill Region, Basar, Arunachal Pradesh. It extends 27° 95' N latitude and 94° 76' E longitude, 662 m above sea level. Experimental site falls under humid subtropical climate. The daily temperature during the study period varied widely between minimum 5.5°C and maximum 32°C, received average annual rainfall of 2 450 mm, with maximum during June to September. The soil of the site was acidic in reaction (pH 5.3), high in organic carbon (Walkley and Black 1.50%), low in available nitrogen (Alkaline permanganate N, 205.6 kg/ha), low in available phosphorus (Bray P, 8.3 kg/ha) and medium in available potassium (Neutral normal ammonium acetate K, 260 kg/ha).

During the study period, various small scale experiments were conducted to establish the impact of agronomic practices on crop yield to support growers of the region to follow the practices to obtain sustainable yield. Maize being a *kharif* crop, grown with recommended agronomic practices developed for Arunachal Pradesh. During post rainy season pea (var. Azad Pea 1) was tested with different set of treatments in randomized block design (RBD) and replicated as the error degree of freedom was not less than 12 except for method of sowing. The experiments mainly consisted of tillage, [no tillage (NT), minimum tillage (MT; one harrowing), and conventional tillage (CT; one moldboard plough and one harrowing)], date of sowing (DOS; 1 October, 15 October and 30 October), method of sowing [broadcasting and line sowing (30 cm × 10 cm)], plant geometry (30 cm × 10 cm, 30 cm × 15 cm, 45 cm × 15, 45 cm × 20 cm), phosphorus management (P; 0, 25, 50 and 75 kg/ha), water management, 5.0 cm of water was applied at each irrigation [no irrigation, one irrigation at 30 days after sowing (DAS) and two irrigation at 30 and 60 DAS] and weed management (no weeding, one hand weeding at 25 DAS) and two hand weeding at 25 and 50 DAS).

During the experimentation, the pod yield was recorded from net area of 2.4 m² (1.2 m × 2.0 m). Under tillage experiment, root samples were collected carefully from the field at the time of flowering to record length and dry biomass with standard procedure, whereas soil organic carbon (SOC) was determined using Walkley and Black method. The P removal was estimated from the total dry

biomass, whereas P use efficiency was worked out with the ratio of P removal to P supplied. Crop was subjected to irrigation during 30 and 60 DAS with 5 cm of water depth with respect to treatments. The amount of rainfall received was considered as effective rainfall and soil moisture contribution was also considered in total water use including volume of water irrigated. Weed count and sampling of weeds were done by using a quadrat size 0.25 m × 0.25 m. The analysis of variance of the data was carried out, using SAS 9.2 software and treatment mean differences were separated by the least significant difference (LSD) test at 0.05 probability level.

RESULTS AND DISCUSSION

Tillage

The results indicated that all the tillage practices influenced the root growth and pod yield of pea ($P < 0.05$; Table 1). It was observed that higher pod yield (29.4%) was obtained with MT followed by CT (19%) than the NT. The length and dry biomass of roots were 70.9 and 60.8% respectively higher with CT followed by MT (43.3 and 40.2%, respectively), but were statistically comparable, while, the lowest was for NT. This was mainly due to CT and MT provided the congenial soil conditions and favoured the plants to grow, develop and accumulate higher dry biomass (Lampurlanés and Cantero-Martínez 2003). This also conserved the soil moisture in sufficient range at root zone and minimum weed growth under MT (Saha *et al.* 2010). Under CT water loss was faster due to better air circulations, therefore, plants failed to obtain soil moisture during dry spell. But, MT provides the congenial condition for growth and development. NT plots were severely infested by broad leaved weed flora like *Ageratum conyzoids*, *Galinsoga parviflora*, *Boreria hispida*, *Cromolina odorata*, *Commelina banghalensis*, grasses weed flora like *Echinochloa colona*, *Cynodon dactylon*, *Paspalum scrobiculatum*, *Digiteria singuanalis* and sedge flora like *Cyperus rotundus* which resulted in higher competitions for available resources at the site. The soil organic carbon (SOC) was improved by 7.3% with NT, whereas MT and CT have reduced by 0.7 and 4.0%, respectively (Fig 1). The improvement of SOC in NT and similar content with MT was due to least interference to soil and maintained the available crop residues on surface, which got decomposed

Table 1 Effect of tillage on root character and yield of pea (during 2009-2011)

Tillage	Root length (cm)	Root dry biomass (g/plant)	Pod yield (kg/ha)
No tillage	31.00±2.55 ^b	4.23±0.45 ^b	1818.33±147.52 ^c
Minimum tillage	44.43±4.02 ^{ab}	5.93±0.78 ^{ab}	2353.33±135.12 ^a
Conventional tillage	52.97±4.42 ^a	6.80±1.01 ^a	2163.33±156.86 ^b
LSD ($P=0.05$)	10.18	2.10	128.90

LSD: least significant difference; ± standard deviation from the mean; same letters in same column are not significant and different letters are statistically difference according to LSD ($P=0.05$).

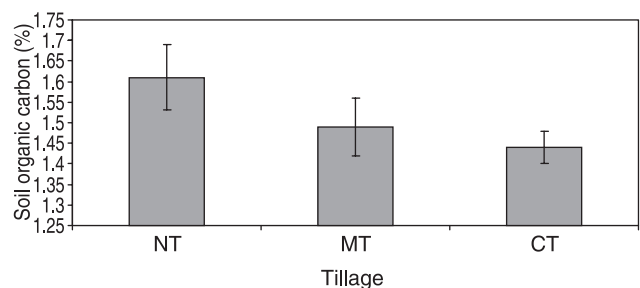


Fig 1 Soil organic carbon (%) as influenced by tillage in pea (± standard deviation from the mean)

and reduced the splash and sheet erosion.

Date of sowing

Data presented in Fig 2a indicated that sowing on 15 October gave significantly higher pod yield ($P < 0.05$) over rest of the sowing dates. Early and late sowing of 15 days over 15 October had yield reduction by 19.4% and 8.8% respectively. The lower yield on 1 October might be due to prevalence of excess moisture during the period, which reduced the germination and emergence led to the reduction in plant population. Similarly, late sown recorded lower yield, as the crop come across water stress and terminal drought during pod formation stages. In addition, late sown crop faced a rapid fall in temperature which initiated flower induction before attaining critical plant canopy resulted lower pod yield (Aziz *et al.* 2011). Excess moisture during first week of October, and rapid fall of temperature during November onwards are unique character of the region. Bhuiyan *et al.* (2008) also reported that the early sowing might be attributed to the dominance of vegetative growth over the reproductive one, but also reported that the late sowing after 4 November significantly reduced the crop yield.

Sowing method and plant geometry

Change in method of sowing increased the pod yield ($P < 0.05$; Fig 2b). Line sown crop harvested 18.2% more pod yield over broadcasting. Line sowing provided sufficient nutrients at site to the plants for better growth and development, which accumulated higher dry biomass to produce better yield attributes. While, broadcasting of seeds increased the competition among plants due to improper space. The earlier finding support that pea requires 30 cm × 10 cm space for better growth and development (Sher *et al.* 2001). Planting geometry with 30 cm × 10 cm obtained 21.4% higher yield followed by 30 cm × 15 cm and 45 cm × 15 cm over 45 cm × 20 cm (Fig 2c). Providing extra spaces in between row increased the weed density, whereas optimum spacing reduced competition for the light, space, as well as above and below ground resources. Thereafter, weed infestation also reduced considerably when plants were sown at optimal density and that crop-weed competition would be minimal that eventually contributed in increasing crop yield (Asaduzzaman *et al.* 2010) in blackgram. Closer spacing might have resulted in the competition for sunlight among the plants. Row spacing of 30 cm produced significantly higher seed, stover and biological yield, resulted higher net returns over 45 cm spacing of pea (Munakamwe *et al.* 2012).

Phosphorus

Table 2 depicted that P at 75 kg/ha increased the yield by 32.3% followed by 50 kg P/ha (20%), whereas 25 kg P/ha had registered increment of 12.9% pod yield over without phosphorus (Table 2). It was noticed that, pea was more responsive to P and recorded higher yield with 75 kg P/ha. The experimental site received an average annual rainfall of

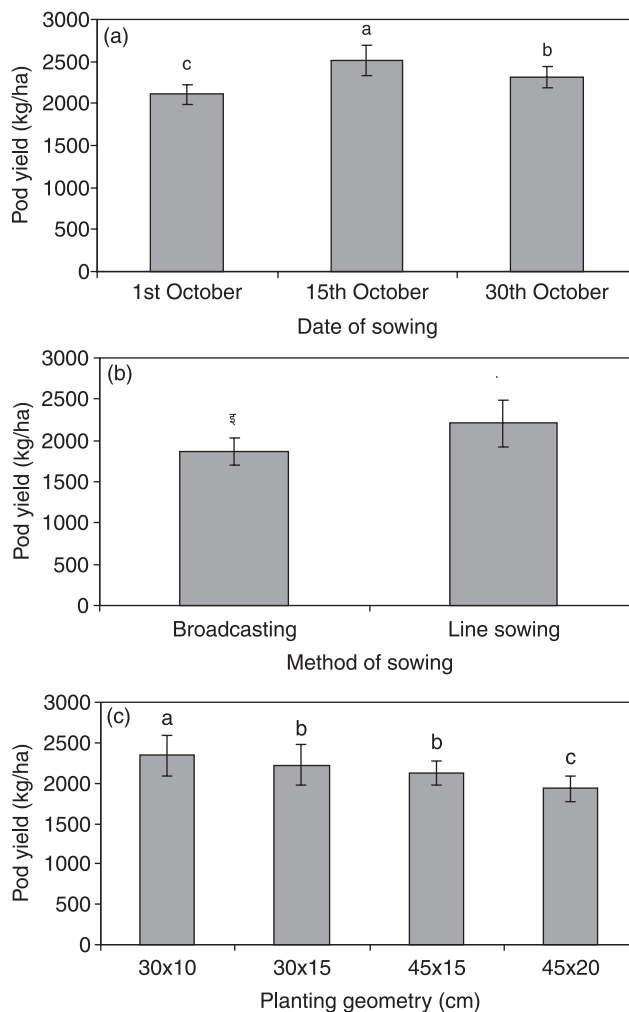


Fig 2 Pod yield of pea during 2008-2010 was influenced by a) sowing time (LSD=138.87); b) method of sowing (LSD=118.81) and c) planting geometry (LSD= 305.87)

Table 2 Yield, phosphorus uptake and phosphorus use efficiency as influenced by different dose of phosphorus in pea (during 2009-2011)

Phosphorus (kg/ha)	Pod yield (kg/ha)	P uptake (kg/ha)	P use efficiency
0	1703.00±130.45 ^c	8.33±0.85 ^d	
25	1923.33±135.12 ^b	12.53±1.21 ^c	0.501
50	2213.33±167.99 ^a	16.63±1.50 ^b	0.333
75	2253.33±155.09 ^a	22.07±2.67 ^a	0.294
LSD ($P=0.05$)	88.40	2.86	

2 450 mm, thus, most of the soluble salts were leached and drained out, and as a result soil became acidic which ultimately restrict the availability of P. Pea required higher P for early establishment, root development and nodule formation (Singh and Agarwal 2004). Higher uptake of P was noticed with 75 kg P/ha followed by 50 kg P/ha and lowest uptake in without P (Table 2). Phosphorus use efficiency (PUE) was 50.1% higher with 25 kg P/ha followed by 50 kg P/ha and lowest with 75 kg P/ha. It was noticed

Table 3 Effect of water management on yield and water use efficiency of pea (during 2009-2011)

Irrigation	Effective rainfall (mm)	Soil moisture contribution (mm)§	Total water use (mm) †	Pod yield (kg/ha)	WUE (kg/ha/mm)
No irrigation	174.2	17.4	191.6	1823.33±145.09 ^c	9.52±0.24 ^a
One irrigation at 30 DAS	174.2	12.4	236.6	2053.33±187.09 ^b	8.68±0.19 ^b
Two irrigation at 30 and 60 DAS	174.2	9.4	283.6	2343.33±235.08 ^a	8.26±0.20 ^b
LSD ($P=0.05$)				134.75	0.58

WUE: Water use efficiency; §: the difference of soil moisture content from beginning to final; †: includes effective rainfall, soil moisture contribution and irrigation water applied.

that the highest PUE with lower P level and consequently it decreased with increment of P levels.

Water management

Irrigation at 30 and 60 DAS significantly ($P<0.05$) improved the pod yield by 28.5% followed by irrigation at 30 DAS (12.6%) over no irrigation (Table 3). From the experimental findings, we presume that at prevailing condition pea required 191.6-283.6 mm water. It was observed that at 60 DAS plants were in flowering, irrigation at this stage induced the plant to produce more flower and resulted higher pods/plant. Therefore, as per the availability of water irrigation may be scheduled to obtain the higher yield than no irrigation. Under limited water condition, at least irrigation at 30 DAS may be scheduled. The higher yield in irrigated plots was mainly due to higher leaf turgor led to enhanced photosynthesis and finally contributed to better dry biomass production and allocations (Dodd 2005). The water use efficiency (WUE) was 15.3% more with no irrigation followed by irrigation at 30 DAS (5.1%) and lowest with two irrigations at 30 and 60 DAS.

Weed management

The experimental field was dominated by natural infestation of broad leaved, grasses and sedge (as described earlier). Twice hand weeding at 25 and 50 DAS increased the pod yield by 39.6% which was considerably higher than one hand weeding at 25 DAS (27.5%), while the lowest dry weed biomass was obtained in no weeding plots (Table 4). In contrary to these, dry weed biomass at harvest was the lowest with two hand weeding followed by on weeding. The

Table 4 Effect of weed management on yield and weed dynamics of pea (during 2009-2011)

Weed management	Pod yield (kg/ha)	Weed dry weight (g/m ²)	Weed control efficiency (%)
No weeding	1536.67±140.42 ^c	7.82±0.37 ^a (60.67)	
One weeding at 25 DAS	1960.00±150.00 ^b	5.91±0.20 ^b (34.47)	43.2
Two weeding at 25 and 50 DAS	2145.67±198.44 ^a	4.87±0.32 ^c (23.23)	61.7
LSD ($P=0.05$)	126.67	0.60	

Figures in parenthesis are original values.

weed control efficiency (WCE) was registered to the tune of 61.7% with two hand weeding followed by one weeding (43.2%). Pea responded better with first hand weeding, later crop canopy cover the ground and restricted the weeds to develop. Thus, the response of second weeding was not that much promising but still improved the yield by 12.1%. Weeds were effectively and timely controlled with two hand weedings, which does not allow the weeds to regenerate. The findings are in conformity with the earlier work of Singh and Agarwal (2004).

Results obtained from the present experiment infer that the suitable site specific packages of practices are recommended to obtain maximum yield. Growers and extension functionaries are advocated as per the convenience or resources available at site to obtain higher pod yield of pea after rainy season crop. Sowing of pea with minimum disturbance of soil in line during 15 October with a spacing of 30 cm × 10 cm along with 50 kg P/ha is good to harvest better crop. Similarly, as per the availability of water two irrigations may be followed at 30 and 60 DAS and under limited water at least one irrigation may be followed at 30 DAS, along with two hand weeding at 25 and 50 DAS for obtaining maximum yield potential but under limited manpower at least one hand weeding at 25 DAS may be followed also get substantial pod yield of pea.

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