CHAPTER II

REVIEW OF LITERATURE
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The main objective of the present investigation was to assess the nutrient requirement for maximization of yield of kharif groundnut, field pea and summer groundnut in groundnut–field pea–summer groundnut cropping system. The secondary objective of the study was to worked out the yield of different crops of groundnut–field pea–summer groundnut. According the available literature it has been presented under appropriate heads.

The importance of application of balance fertilizers for NPK in maintaining the productivity and fertility of soils needs no emphasis. The nutrient input requirements have gone up. Several fold with the availability of high yielding and highly nutrient responsive varieties of crops, resulting in rapid turn-over of plant nutrient in soil plant systems. In integrated nutrient plant system, the addition of deficient nutrient like sulphur for oil seeds and legumes has become necessary besides the inclusion of organic sources of nutrients. A brief review of the past researcher has been given on this aspect in groundnut, pea and allied crops.

2.1 Brief history of summer groundnut cultivation in U.P.

The northern belt of alluvial soil of Uttar Pradesh having loamy sand, sandy loam and light loam texture is ideal for groundnut cultivation in rainy season. In the early 1980s groundnut was grown in Uttar Pradesh on 0.3 million ha with a production of 0.19 million tones. Since then both area and production have sown a steady decline. In
2002-03, the groundnut area was reduced to 0.09 million ha with a total production of 0.06 million tones and an average productivity of 660 kg/ha. Efforts to arrest this decline in area and production did not succeed due to various biotic and economic reasons. A strong need was felt to develop a suitable technology for groundnut cultivation under water limited conditions to revive groundnut in the state. Since the main function of the National Agricultural Research Project (NARP), Mainpuri is to lead the groundnut research, the scientific team of the project started work. On summer groundnut in Uttar Pradesh under the leadership of Dr. R.A.Singh, Professor/Chief Scientist-Agronomy International Crop Research Institute for the Semi-arid Topics (ICRISAT), Patancheru supplied 29 improved groundnut genotypes for evaluation during summer season in 1998. Genotypes ICGV 93468 of ICRISAT and Dh 86 of UAS, Dharwad gave very good performance during summer season and at initial stage both cultivars gave more than 2.0 t/ha pod yield after 85–90 days of planting. Varieties 93468 (Avtar) and Dh 86 were considered safe for farmers. Cultivar Dh-86 was released from UAS Dharwad from the genotype line of D4D8-10. At present both varieties are equally responding on farmers fields with yield level of 3.0 to 3.5 t/ha. This was the first unprecedental success for dissemination and diffusion of groundnut during summer season of Uttar Pradesh. Thus, the area under summer groundnut cultivation increased from scratch in 2001 to 63,710 ha during 2006 and 85290 ha during 2007 through farmer to farmer spread (Source : NRCG Newsletter).
2.2 Effect of sequential cropping and integrated nutrient management on growth, yield traits and yield of groundnut.

Singh (2006) reported that the cultivar ICGV 93468 gave significantly higher pod yield by 22.49 q/ha followed by Dh 86 (20.81 q/ha) during rainy season, wheat rose after kharif groundnut gave grain yield by 55.66 q/ha. Variety Dh 86 planted after harvesting of wheat yielded 19.02 q/ha pods during summer season. Thus, groundnut cv. ICGV 93468, wheat cv. Malvial 234 and summer groundnut cv. Dh 86 gave maximum yield in groundnut – wheat – summer groundnut cropping system at their respective RDF and 100 q/ha FYM inoculated with vermicompost @ 5 q /100 q FYM used before the planting of rainy season groundnut.

Singh (2007) stated that the application of 20 kg N + 50 kg P₂O₅ in combination of FYM @ 10 t/ha registered significantly higher growth, yield components and grain yield of green gram (5.29 q/ha) over control and conventional system of RDF. Likewise, the integration of residue of FYM @ 10 t/ha with 120 kg N + 40kg P₂O₅ + 40 kg K₂O/ha pushed up significantly to growth and yield traits of mustard which culminated into significant increase in seed yield of mustard (24.48 q/ha). Application of 15 kg N + 30 kg P₂O₅ + 45 kg K₂O/ha in conjunction with remaining residue of 10 t FYM/ha gave significantly higher pod yield of summer groundnut by 22.21 q/ha over control and conventional system of RDF. The growth and yield contributing characters noted in groundnut were concordant to the pod yield of groundnut.

Singh (2006) reported that among the eleven varieties of summer groundnut tested under groundnut–mustard–summer groundnut cropping system under their respective RDF. The groundnut cultivar
Dh 86 and ICGV 93468 registered significantly higher pod yield during summer season. The order of varietal performance was Dh 86 & ICGV 93468>R 9251>R 2000–1>TG 37 A>ICGS 1>ICGS 544> ICGV 86590 & R 8808>G 201>Dh 86 during summer season under groundnut—mustard—summer groundnut cropping system.

Singh (2005) and Singh (2007) stated that the yield of different enterprises in maize-potato-summer groundnut harvested 27.40 q/ha of maize, 264.60 q/ha of potato and 27.00 q/ha of summer groundnut. The yields of maize, field pea and summer groundnut reaped as 25.22 q/ha, 32.00 q/ha and 30.00 q/ha, respectively their respective RDF. The newly introduced cropping system maize—mustard—summer groundnut on partially reclaimed sodic land gave 25.00 q/ha of maize, 29.50 q/ha of mustard and 23.40 q/ha of summer groundnut.

Singh (2007) indicated in his study that the summer groundnut responded to the application of 60 kg K₂O/ha which was registered significantly higher pod yield (29.02 q/ha) over 45 kg K₂O/ha (25.90 q/ha). Similarly, application of 45 kg S + 60 kg Ca/ha through gypsum gave significantly higher pod yield by 32.47 q/ha compared with lower installments of S + Ca to summer groundnut under irrigated condition. The growth and yield traits noted in groundnut under variable doses of K₂O and S + Ca were concordant to the pod yield of groundnut. Therefore, integration of 60 kg K₂O + 45 kg S + 60 kg Ca with 20 kg N + 30 kg P₃O₅/ha can be used for higher production of pods of groundnut during summer season.
Singh (2005) reported from Zonal Agricultural Research Station, Mainpuri that the variable doses of K₂O @ 45 and 60 kg/ha, S @ 0, 15, 30 and 45 kg/ha, and Ca @ 0, 30, 60 and 90 kg/ha were tested with common dose of N (20 kg/ha) and P₂O₅ (30 kg/ha). Application of 60 kg K₂O/ha registered significantly higher pod yield over lower dose of K₂O. Likewise, the maximum tested dose of 45 kg S + 90 kg Ca/ha also gave significantly higher pod weight over lower doses of S and Ca during summer season. The integrated dose of 20 kg N + 30 kg P₂O₅ + 60 kg K₂O + 45 kg S + 90 kg Ca gave pod yield of 3.26 t/ha in Dh 86.

Singh (2004) conducted a trial with seven levels of farm yard manure (FYM) (0, 2, 4, 6, 8, 10 & 12 t/ha) with recommended dose of fertilizers (20 kg N/ha + 30 kg P₂O₅/ha + 45 kg K₂O/ha + 200 kg gypsum/ha) during summer season of 2002 & 2003. Treatment with 10 t FYM/ha in conjunction with RDF produced significantly higher pod (2.98 t/ha) in comparison to lower doses of FYM. The highest dose of 12 t FYM/ha in combination with RDF did not increase the pod yield further.

Singh (2004) reported from CSAUAT, Kanpur that the application of FYM @ 10 t/ha in association of RDF (15 kg N + 30 kg P₂O₅ + 45 kg K₂O + 250 kg gypsum/ha) to ICGV 93468 during kharif season registered significantly higher pod yield over control, RDF and FYM (2 to 8 t/ha). The further installment of FYM stagnated the pod yield of groundnut. The yield of groundnut pushed up due to better availability of trace nutrients and good moisture retaining capacity of soil under combined application of chemical fertilizers and FYM.
Singh et al. (2005) stated that the application of sulphur @ 20, 40
60 kg/ha gave 18.8, 27.5 and 29.2 % higher pod yield of groundnut over
the control. Residual effect of sulphur @ 20, 40 & 60 kg/ha application
increased the grain yield of wheat by 10.4, 20.7 and 22.4 %, respectively, over control in groundnut-wheat cropping system.

Hago and Salama (1987) reported the role of sulphur in
increasing yield mainly attributed to early flowering and more pod
setting in groundnut. Sakal et al. (1995) also reported an increase in pod
yield of groundnut upto 20 kg S/ha.

Rao and Shaktawat (2002) reported that the application of FYM
@ 10 t/ha and poultry manure @ 5 t/ha increased the pods/plant, pod
weight/plant, sound mature kernel % and 100-kernel weight of
groundnut compared with control. Sulphur provides sink strength
through development of reproductive structure and production of
assimilates to fill economically important sink. Calcium plays an
important role in the reproductive development of groundnut.

Dayanand and Meena (2002) reported from Jobner, Rajasthan
that the groundnut responded to sulphur application upto 40 kg S/ha,
where as higher groundnut pod equivalent yield, net return and benefit :
cost ratio were obtained with 60 kg S/ha. All the growth parameters
showed an increasing trend with increasing level of S upto 60 kg/ha,
though the increase in dry weight of root nodules beyond 40 kg S/ha
was not significant.
Kathmale et al. (2000) stated that the significantly higher dry pod and haulm yield of kharif groundnut were observed due to application of 2.5 tonnes FYM + 75% recommended dose of fertilizer which is 57% higher than of control and 31% higher than of farmers practice.

Bandopadhyay and Samui (2000) reported from Nadia that the application of 30 kg S/ha increased pods/plant, kernels/pod, 100-kernel weight, pod yield (g/ha), kernel yield (q/ha), haulm yield (q/ha), oil content (%) in seed and oil yield (q/ha) over the control.

Badole (2001) a field experiment was conducted in Parbhani, Maharashtra, India, using kharif cotton and succeeding summer groundnut. Various organic and inorganic nutrient sources. Organic treatment recorded higher dry pod and haulm yield over inorganic treatment. The treatment involving inoculation of phosphate sulbulizing bacteria. (Ph.D.) produced higher dry pod and haulm yield.

Sankaranarayan et al. (2000) reported that the improved cultivation practices resulted in better value for mean pod yield (1270 kg/ha) intercrop yield (414 kg/ha) net return (11649 Rs./ha) cost benefit ratio (2.57) in groundnut and pigeon pea intercropping.

Trivedi et al. (2001) reported that application of 20 : 40 : 20 kg NPK/ha with basal application of 3 kg PSB/ha gave the maximum pod yield of 1336 kg/ha, which was 260 kg/ha more than that of recommended dose of NPK (20 : 80 : 20 kg/ha). The highest monetary return Rs. 4380/ha) was also obtained from the same treatment.
Sahu et al. (2001) showed that the application of S at 40 kg/ha or 50 kg/ha through phosphogypsum produced significantly higher yields, selling percentage, oil content and uptake of S. Integration of S source at 30 kg/ha increased pod yield along with other associated character over other treatments. Maximum pod yield, selling turn over oil content and uptake of S were recorded in the integrated treatments of phosphogypsum with poultry manure in groundnut crop.

Ramesh and Savale (2001) reported that pod yield of summer peanut was significantly higher under 75 kg P₂O₅/ha application along with P₃ solubilizer and with a population density of 0.33 million plants/ha (3x10 cm.) Similarly, higher protein percentage and oil content were also observed with 0.33 million plants/ha, P₃ solubilizer and 75 kg P₂O₅/ha.

Saroj et al. (2001) reported that the high agronomic efficiency of SSP placement (4 kg P ha⁻¹) across sites could be explained by consistent increase in the quantity factor which confirms the power of the isotopic exchange method in explaining management effects on crop growth across the reason.

Rathi et al. (2000) reported that a farmer participatory trial was conducted in red and lateritic soils of Kalahandi district of Orissa, India, during the winter season of 1992-93 and 1993-94 to study the efficacy of different sources and levels of phosphorus (P) on the growth of yield of groundnut cv. ICGS 11. The highest pod (24.13 q/ha) and haulm yields (46.55 q/ha) were with DAP alone. An almost similar trend was observed in oil yield. The highest oil yield of 8.58 q/ha was obtained
from the 50% SSP + 50% MOP treated plots. In terms of P levels, 75 kg/ha recorded the highest pod yield (24.51 q/ha) whereas the highest yield was obtained upon treatment with 50 kg/ha due to a high selling percentage and oil content.

Tamoli and Daftardar (2000) found that the application of KH₂PO₄ recorded the significantly highest inorganic P fractions, Olsen-P, yield and P uptake over AlPO₄ or FePO₄ for groundnut and FePO₄ for pigeonpea. Both the soil series of Vertisol proved significantly better than the Wakawali soils series of Alfisol for inorganic P fractions, Olsen, P, dry matter yield and P uptake by pigeonpea and groundnut. The coefficient of correlation between yields P uptake and Olsen, P were highly correlated with the different inorganic P fractions in soils barring few exception for both legume. Among the different inorganic P fraction of Vertisols Ca-P was the most important P fraction for P nutrition of groundnut while it was Fe-P fraction for pigeonpea. In Alfisols Fe-P was the best closely followed by Ca-P for P nutrition for pigeonpea, while Fe-P was the best closely followed by Ca-P for P nutrition of groundnut.

Kathmale et al. (2000) reported that a field experiment was conducted to assess the fertilizer requirements of a sorghum bicolor cv, CSH-14-groundnut (Arachis hypogaea cv. ICGS-11) cropping system on Vertisol of the western Maharastra plains zone, India. The full recommended NPK dose (120 : 60 : 60) was applied to sorghum in the kharif season and fertilizer treatments were applied to groundnut in the summer season. Sorghum yield was not affected due to the residual effect of the fertilizer supplied to the summer groundnut. Dry pod and haulm yields of the summer groundnut.
Rekha and Reddy (1999) found in a field experiment in 1994/95 in Andhra Pradesh with groundnuts, found that the application of 40 or 80 kg P₂O₅/ha and 10 t farmyard manure/ha did not significantly effect/pod yield. However, phosphorus reduced total N uptake while farmyard manure increased uptake of N and K. Seed treatments with 3 g molybdenum/kg seed increased total uptake of P and K while in combination with 80 kg P₂O₅ ha⁻¹ improved pod yield by 30 or 60 % over 1.5 g and no molybdenum levels, respectively.

Dudhatra et al. (2002) found that treatment 100% recommended dose of fertilizer (12.5, 25 and 0 kg N, P and K/ha) with crop residue (1.5 tonnes/ha+FYM) or (grain manure at 5 tonnes/ha) alongwith 30 % higher plant density resulted in the highest pod and haulm yields of groundnut as well as green and straw yields of wheat. Normal tillage in the rainy season and reduced tillage in the winter season with incorporation of various inputs enhanced the total uptake of nutrients (N, P and K). Integrated input management increase uptake by crop and soil status. After 6 years of cropping system, the net amount of N and P added to the soil ranged from 244 to 413, and 343 to 409 kg/ha, respectively, while the depletion of K ranged from 123 to 323 kg/ha. The highest net returns were obtained under reduced tillage in winter and under higher input levels. The highest net returns of Rs. 31366/ha with benefit : cost of 2.95 was obtained under reduced tillage. Higher net returns (Rs 31219/ha) with higher benefit : cost ratio (2.65) were obtained under integrated nutrient management alongwith 30% higher plant density treatment.
Akbari et al. (2002) showed that data revealed that application of FYM at 10 tonnes/ha obtained higher additional return than without FYM application, furthermore, application of P at alternate year recorded higher traditional return, benefit and incremental cost benefit ratio while lowest values were attained when available P, K and S status in soil after harvesting of groundnut. P application significantly affected organic C and available P but available K and S content were not altered.

Chaudhary and Jadhav (2002) found significant increase in the pod yield of the crop. Differences in effects of sulphur at 40 kg/ha were not observed, although sulphur application was better than non application of sulphur.

Badole et al. (2001) reported that the residual effect of integrated nutrient supply system (50% NPK through chemical fertilizer + 50 % NPK through FYM+Azo+CDUS+PSB) was the greatest, recording the maximum dry pod yield (2537.62 kg/ha) and haulm yield (4388.72 kg/ha) of groundnut. The treatments involving inoculation of PSB produced higher dry pod and haulm yields compared to uninoculated treatments. Among the organic treatments, the combination of different organic sources (FYM+PMC+glyricidia+Azo+PSB+CDUS) was found superior. A similar trend was observed with respect to protein and oil contents.

Thakre et al. (2002) reported that the highest N, P and K contents of kernel and haulm were recorded for the combined application of Rhizobium and PSB with inorganic fertilizer and manure, which favourably improved the nutrient uptake by groundnut.
Badole et al. (2004) reported that 50 % NPK through chemical fertilizer + 50 % NPK through FYM + Azo + CDUS + PSB recorded maximum dry pod yield and brought about height monetary returns in summer groundnut. Results suggest that different organic manure and results have a positive residual effect on succeeding ground soul crop.

Behera and Jha (2000) showed that the cultivars responded significantly to P and K application with 36-48 and 31-57% improvement in pod yields, respectively, in the red soils. A maximum response of 9.70 kg pod/kg P, a return of Rs 10.84 per rupee invested on P fertilizer and a return of Rs 3.66 per rupee invested on production input was obtained upon treatment with 30 kg P/ha. A similar response was obtained upon treatment with 30 kg K/ha.

Nguye-Cong-Vinh (2003) found that in a pod experiment, farmyard manure reduced P absorption from 99.7% in the control to 87.2%. Higher seed and pod yields were obtained with farmyard manure+fused magnesium phosphate than with farmyard manure+single superphosphate, particularly for pod yield. Seed out-term was enhanced by farmyard manure.

Singh et al. (1998) on cropping system of groundnut-vegetable pea-summer groundnut. 33 summer groundnut cultivars were tested. Cultivars D4D8–10, D4D8–14, ICGV–93468, ICGV–96360, ICGV– 95337 were found most suitable and yielded 17.54, 17.17, 16.31, 12.97 and 12.45 q/ha pods, respectively.

Singh (1999) to judge the efficacy of four level of N + P2O5 + S + Ca on dwarf field pea after groundnut. Field pea responded upto 25 kg N + 50 kg P2O5 + 15 kg S + 30 kg Ca/ha significantly and the additional
grain of field pea was reaped 12.86 q/ha (60.40 %) over no nutrients used. This combination of nutrients proved most suitable for degraded sandy soils under groundnut – field pea cropping system.

Singh (1999) reported that the integrated use of recommended dose of N$_{20}$, P$_{30}$ and K$_{45}$+FYM @ 100 q+gypsum @ 300 Kg/ha resulted in significantly higher pod yield of groundnut (9.38 q/ha) followed by N$_{20}$, P$_{30}$ and K$_{45}$+FYM @ 100 q+gypsum @ 300 kg+neem leaf powder @ 100 kg/ha (9.28 q/ha). The growth and yield contributing traits of groundnut were consistent to pods yield. The residue of N$_{20}$, P$_{30}$ and K$_{45}$+FYM @ 100 q+gypsum @ 300 kg+neem leaf power @ 100 kg/ha and application of N$_{20}$+P$_{40}$ to wheat gave higher grain yield of wheat by 46.24 q/ha than other treatments under late sown condition. The growth and yield-contributing characters noted in wheat were concordant to the grain yield.

Singh (2000) reported that the use of FYM @ 100 q/ha+release of earthworm @ 60,000/ha gave higher pod yield of peanut as compared with other treatments. Likewise, the release of earthworm in peanut significantly increased the yield of succeeding crop of vegetable pea (23.62 q/ha) over all the treatments except use of FYM @ 100 q/ha in combination of vermin culture @ 60,000/ha (24.10 q/ha). Thus, the peanut and vegetable pea could successively be raised under sequential cropping with the use of FYM @ 100 q/ha+vermiculture @ 60,000/ha to peanut and 15 kg N+40 kg P$_2$O$_5$/ha as starter dose to vegetable pea alongwith better management of natural resources residue for higher productivity and monetary return.
2.3 Effect of sequential cropping and integrated nutrient management on nutrients uptake by groundnut

Singh (2007) reported from Zonal Agricultural Research Station, Mainpuri that the uptake of NPK was increased under green gram-mustard-summer groundnut cropping system, when three crops fertilized with their respective RDFs in association of FYM applied before planting of green gram. Analysis of soil after harvesting of different crops of the sequence showed a significant build up of NPK with the application of FYM. The population of earthworms was higher in the soil receiving plenty of FYM, inoculated with vermin compost.

Singh et al. (2005) reported that the sulphur uptake by groundnut pods increased significantly with increasing levels of sulphur from 20 kg S to 60 kg S/ha and maximum uptake (10.89 kg/ha) was noticed with application of 60 kg S/ha.

Rao and Shaktawat (2002) stated that application of FYM @ 10 t/ha and poultry manure @ 5 t/ha increased uptake of NPK, S, Ca and Mg significantly over the control. The magnitude of increase in mean uptake if N, P, K, S, Ca and Mg dye to FYM was 20.1, 17.2m 15.1, 13.9, 15.7 and 13.7 % over control. It appears that availability of these nutrients increased in soil under organic manure application as reflected by higher pod and haulm yields of groundnut that have resulted into more uptake of these nutrients.

Rao and Shaktawat (2002) stated that application of S in the form of gypsum significantly increased the accumulation of N, P, K, S, Ca and Mg in the plants at harvest. This could be ascribed to their greater availability in root environment along with extraction and transportation towards plant system.
2.4 Effect of PSB culture on growth, yield traits and yield of groundnut

Panwar and Singh (2003) observed that single inoculation of Rhizobium and PSM marginally improved the pod and haulm yields of groundnut but their combination use significantly improved pod yield 28.80% higher over that of the control (19.62 q/ha). It indicated that when both cultures applied together had synergistic effect on each other and gave more yield. Application of FYM or neem cake also improved the yield by 41.84% and 41.43% over the control, respectively, but when half quantity to these organics was integrated with both the bio-fertilizer the improvement in yield was 59.56% and 53.38% in the order.

Kathmale et al. (2002) reported that the farmers practice supplemented with rhizobium and phosphorus-solubilizing micro-organisms significant increased the dry pod yield of groundnut.

2.5 Effect of sequential cropping, integrated nutrient application on growth, yield traits, seed yield and nutrient uptake of pea.

Phogat and Bisnoi (1996) reported from Hisar (Haryana) the significant increase in number of branches, dry matter accumulation per plant and harvest index up to 31.23 kg N/ha.

Singh et al. (1992) have observed significant increase in number of pods per plant, branches per plant and 1000 seed weight in field pea up to the application of 30 kg N/ha. Srivastava and Verma (1986) conducted an experiment at B.H.U., Varanasi and reported positive effect of 20 kg N/ha on almost all growth attributes of field per over
control. In their study, Ivany (1986) observed significant positive effect of increasing doses of nitrogen on pods per plant, seed per pod and 1000-seed weight of pea.

Saini and Thakur (1996) reported that application of 30 kg N/ha significantly increased pods/plant, grains/pod, pod weight/plant, leaf area index and all the growth characters over control but 30 and 60 kg N/ha were at par. Yadav et al. (1996) have tried four varieties of table pea at different levels of fertilizers and reported that application of nitrogen (at) 40 kg/ha increased the number of days to flowering and marketable maturity.

Bisen et al. (1985) reported significantly increase in dry matter/plant, plant height, number of pods/plant and pod weight/plant with increasing rates of nitrogen up to the maximum tested dose of 80 kg/ha.

Elneklawy et al. (1985) conducted a field study on table pea at Kalabsha valley (Himachal Pradesh) and reported that application of 60 kg N/ha increased fresh and dry weight of plant, while same dose inhibited nodulation.

Phogat and Bisnoi (1996) have tried 3 varieties of dwarf pea at different doses of fertilizer and reported significant yield response up to 31.23 kg/ha. Bahal et al. (1995) tried dwarf pea at different doses of nitrogen upto 60 kg/ha and reported significant response in seed yield up to 40 kg N/ha.

In a study conducted by Ali (1994), dwarf field pea variety 'Aparna' responded significantly upto the application of 60 kg N/ha with seed yield response of 498 kg/ha over control. Some other research workers have also reported significant response of dwarf field pea up to 40 kg N/ha (Singh et al. 1994).
Ali (1989 b) when summarizing the results of All India Coordinated Agronomic Trials reported that 200 kg N/ha at Dholi and 30 kg N/ha at Navgoan was optimum for seed production of field pea. Reported increase in the seed yield of dwarf pea continuously upto 60 kg N/ha at Navgoan and 40 kg N/ha at Pantnagar. Ali (1987) observed significant yield increase up to the application of 60 kg N/ha in case of dwarf field pea.

Azad et al. (1992) have tried 0, 15, 30, 37.5 and 45 kg N/ha in pea on soils having different organic carbon status. They reported grain yield response from 425 to 924 kg/ha with increasing doses of nitrogen from 15 to 45 kg/ha over control. Response was low in soils having high carbon content and vice-versa.

Negi (1992) has tried nitrogen upto 60 kg/ha on vegetable pea and estimated maximum significant yield at 20 kg N/ha only. Study of Minar and Zehnalek (1991) indicated higher seed yield of pea at medium dose of nitrogen application. Singh and Naik (1990) have studied the response of table pea cv. Arkel to four levels of nitrogen (0, 25, 50 and 75 kg/ha) and reported the yield response up to the highest tested dose of 75 kg N/ha.

Pachauri et al. (1988) tried three levels of nitrogen (0, 37.5 and 75 kg N/ha) and reported highest seed yield of vegetable pea with the application of 75 kg/ha. Bisen et al. (1985) observed significant increase in pod yield up to the highest dose of 80 kg N/ha.

Boiko (1979) reported from Ukrain that highest seed yield of pea was obtained with the application of 60 kg N/ha. Borcean et al. (1979) have reported that seed yield of pea increased from 1.54 t/ha in control to 2.15 t/ha with 48 kg N/ha dose. They supported such higher yields with increase in pod/plant and grain/pod.
Ahmad and Shafi (1978) have tried 0, 60 and 90 lbs N/acre on pea in Pakistan and found that yield increased with increasing levels of nitrogen.

Naik (1992) reported significant increase in grain yield of garden pea with increasing doses of nitrogen up to 50 kg/ha but shelling percentage was maximized at 25 kg N/ha. Highest pod yield of garden pea and shelling percentage was observed at 60 kg N/ha in the study.

Shahein (1996) reported from Egypt that uptake of NPK increased with the application of increasing dose of N and P fertilizers.

Sati et al. (1991) reported from Pa.inagar that nitrogen fertilization @ 25 N/ha significantly increased the N content in pea plants over control. In studies of Srivastava and Verma (1986) the nitrogen content in grain and straw of pea increased with increasing nitrogen doses up to 40 kg/ha but the increase beyond 20 kg/ha N dose was not significant. Phosphorus content in grain and straw was statistically not affected by nitrogen fertilization. Sambhi and Grewal (1986) found in their study that application of 50 kg N/ha gave best quality pea cv. ‘Hara Bonna’. Elmekawy et al. (1985) have observed increased N-uptake in pea at the dose of 60 kg N. feddan under Egypt condition.

Rubes (1984) reported from Czechoslovakia that pea seed contains significantly higher N with the application of 30 kg N/ha over control. Best quality seed of vegetable pea was obtained with the application of 15 kg N/ha in the study of Fonter et al. (1982).
Maurya and Prasad (1997) have tested phosphorus upto 90 kg P₂O₅/ha and reported that dwarf field pea gave significantly higher grain and straw yield and seed weight per plant at highest dose of 90 kg P₂O₅/ha.

Phogat and Bisnoi (1996) reported that highest grain yield of dwarf pea was obtained at 60 kg P₂O₅/ha but significant response was observed upto the dose of 50 kg P₂O₅/ha. Ali (1989) found that dwarf field pea significantly responded in case of yield upto 60 kg P₂O₅/ha. In the study of Chauhan et al. (1991), significant increase in seed and straw yields of pea were recorded with the application of 40 and 80 kg P₂O₅/ha over control, respectively.

Yadav and Chauhan (1997) tried 4 levels of P₂O₅ (0, 25, 50 and 75 kg/ha) and found that tall pea responded significantly only upto first dose of 25 kg P₂O₅/ha. In their study, Rathi et al. (1995) found that application of 40 kg P₂O₅/ha in P deficient soils greatly increases the pods/plant, pod length, seeds/pod and seed yield of pea. A dose of 30 kg P₂O₅/ha was reported optimum for seed yield of tall pea by Bahal et al. (1995).

Yadav et al. (1992) observed that phosphorus application in pea @ 25 kg P₂O₅/ha significantly improved pods per plant and grain yield over control. However, increase in yield over 25 kg P₂O₅/ha was narrow which was explained due to medium content of P in soil.

Singh et al. (1981) reported from Kanpur that higher grain and straw yields of pea were obtained at 60 kg P₂O₅/ha over control. Significantly higher grain yield of pea was obtained at highest tested dose of 60 kg P₂O₅/ha in the study of Srivastava et al. (1998).
Verma and Bhandari (1998) in their study found that green pod seed and straw yields of vegetable pea increased with the application of phosphorus upto 60 kg P₂O₅/ha. On the same pattern Kannaujia et al. (1998) found that application of 60 kg P₂O₅/ha gave highest pod yield of 13.17 tonnes/ha.

Srivastava and Ahlawat (1995) tried phosphorus upto 25.8 kg/ha on pea cv. “Arkel” and reported significant increase in number of pods/plant, seeds/pod, test weight and seed yield. Highest mean seed yield of table pea was obtained with the application of 60 kg P₂O₅/ha by Rathi and Sharma (1995).

Naik (1995) have observed highest pod yield of vegetable pea cv. “Bonneville” with the application of 100 kg P₂O₅/ha.

Singh and Bajpai (1991) reported that application of 25, 50 and 75 kg P₂O₅/ha has given 0.84, 1.01 and 1.13 tonnes more pods/ha over control, respectively.

Naik (1992) reported that increasing dose of P₂O₅ increases pod yield of garden pea upto the highest tested dose of 100 kg P₂O₅/ha, but response was significant upto the dose of 75 kg P₂O₅/ha. Pod length improved upto 75 kg while, pod weight upto 50 kg P₂O₅/ha and shelling per cent remains unaffected.

Yadav and Chauhan (1997) when tried phosphorus doses from zero to 75 kg P₂O₅/ha found that N and P uptake by pea crop increased with increasing levels of P but significant increase was recorded only at first does of 25 kg P₂O₅/ha over control. Labynstev (1997) found that P application increased nitrogen concentration in leafless cultivar of pea
by 5-44 per cent while N decreased it by 20-22 per cent. In their studies, Srivastava and Ahalawat (1995) observed that application of 25.8 kg P₂O₅/ha significantly improved N and P-uptake by the pea crop. Deepa and Sadeque (1994) reported from Assam that vegetable pea seeds contained highest crude protein content with the application of 60 kg P₂O₅/ha.

Gyori and Bocze (1992) observed that pea seed N content was increased with the highest NPK rates but tryptophane content reduced at higher P₂O₅ doses. Chauhan et al. (1991) reported that N and P content in seed and straw were not significantly affected by P₂O₅ doses. The high N and P uptake with P₂O₅ application was mainly due to high dry matter production. In their study, Naik et al. (1991) have tested the effect of P₂O₅ doses on N and P uptake at different growth stages of pea. They found that P application upto maximum of 120 kg P₂O₅/ha and significant effect on P-uptake at maturity stage of crop. Dahiya et al. (1990) reported that increasing rates of phosphorus both content and uptake of P in pea crop.

Srivastava and Verma (1986) tried 0 to 90 kg P₂O₅/ha in pea and found that protein per cent in grains and N and P content in grains and straw were higher at increasing levels of P₂O₅ but significant increase was observed upto the dose of 60 kg P₂O₅/ha. Autuono et al. (1985) found that protein per cent in pea seeds increased with the application of 100-200 kg P₂O₅/ha. Singh et al. (1981) found that content and uptake of N, P by seed and straw of pea was highest at maximum level of 60 kg P₂O₅/ha.
Peck et al. (1980) found that increasing levels of P application from 0 to 120 kg/ha increased P content in pea grains. Lenka and Gautam (1972) reported that pea crop with an average production of 22 q/ha grain and 367 q/ha vine removes 123 kg N, 11 kg P and 101 kg K/ha. In their study, Garg et al. (1971) found significant increase in protein and phosphorus content in pea seeds upto the application of 40 kg P$_2$O$_5$/ha.

Pachauri et al. (1988) reported that the highest seed yield of vegetable pea can be obtained with the application of 75 kg N + 150 kg P$_2$O$_5$/ha. Verma et al. (1997) tried nitrogen up to 45 kg and phosphorus upto 90 kg P$_2$O$_5$/ha and observed that 15 kg N and 60 kg P$_2$O$_5$/ha were the optimum doses for maximum yield and high nutrients concentration in pea. Phogat and Bisnoi (1996) studied the effect of three pea varieties (HFP-4, HFP-8712 and HFP-8717), three spacings (20, 25 and 30 cm) and four levels of fertility (18.75 + 30, 31.25 + 50, 25 + 40 and 37.5 + 60 Kg) reported that increasing fertility levels resulted in increased yield attributed and grain yield of pea but differences were significant only upto the level of 31.25 kg N + 50 kg P$_2$O$_5$/ha.

Saini and Thakur (1996) tried different doses of N and P and found that mean green pod yield of pea was highest with the application of 30 kg N + 52.8 kg P/ha. In the studies of Bahal et al. (1995), application of 40 kg N + 30 kg P$_2$O$_5$/ha was found optimum for seed yield and uptake of N and P. Naik (1995) tried 25-75 kg N and 25-100 kg P$_2$O$_5$/ha and found that pod yield of pea was not significantly affected by doses of nitrogen and was highest with 100 kg P$_2$O$_5$/ha.
Singh et al. (1992) have observed seed yield with maximum values of all yield attributing characters at combined application of 18 kg N and 40 kg P₂O₅/ha. In another study, Srivastava and Ahalawat (1995), recorded maximum yield of pea variety “Arkel” with 20 kg N + 25.8 kg P₂O₅/ha due to improved nodulation, high dry matter accumulation, more number of pods/plants and higher numbers of seeds/pod.

Negi (1992) has tried nitrogen upto 60 kg and phosphorus upto 120 kg P₂O₅/ha. He estimated maximum and significant yield at the combination of 20 kg N + 60 kg P₂O₅/ha. Shekhar and Sharma (1991) have tried nitrogen upto 120 kg and phosphorus upto 139.7 kg P/ha. They obtained maximum significant yield and all the yield attributes at the combination of 60 kg N + 69.9 kg P/ha.

Ali (1989 b) when summarizing the results of AIC Agronomic Trials found the dose of 20 kg N + 40 kg P₂O₅/ha as optimum at Dholi and 30 kg N + 60 kg P₂O₅/ha, at Navgaon.

Badiger et al. (1988) found that maximum kernel yield (57.6 q/ha) of groundnut was recorded with treatment of 11.2 kg K₂O and 20 kg S/ha as compared with 40.9 q/ha without potassium and sulphur. The increase in yield of peanut was attributes to potassium, in the presence of adequate supply of calcium to bring about good filling of pods in soil less in potassium Brady and Callwell (1995).

Singh et al. (1997) reported increase in dry matter accumulation in lentil upto 18.50 ppm K.
Sekhon et al. (1997) reported that application of 60 K$_2$O/ha significantly improved the biomass production of cowpea and *Sesbania*, on sandy soil only.

Modal and Goswami (1991) reported maximum pod yield of groundnut when higher dose of potassium (80 kg K$_2$O/ha) was applied in split doses.

Deshmukh et al. (1993) stated that yield of groundnut was improved by application of P and K up to 50 kg P$_2$O$_5$ and 75 kg K$_2$O/ha, respectively. They also reported increase in NPK uptake on application of P and K.

Potassic fertilization is not a common practice due to reason of medium to high K status of soils in Uttar Pradesh. However, response to K has been reported by some researchers under varying soils, crop rotation conditions and at higher levels of other nutrients especially nitrogen in different crops.

Yadav et al. (1993) reported highest yield response in pea and pearl millet when 60 kg K$_2$O/ha was applied in two split doses along with 120 kg N and 60 kg P$_2$O$_5$/ha.

Tiwari and Agrawal (1993) reported that added potassium caused a week earlier flowering of gram than the controlled treatments.

Sharma et al. (1993) reported significant increase in dry weight of nodules of cluster bean by use of potassium which also increased the gum content percentage.

Saroja and Sundaram (1993) stated that 40 kg K$_2$O/acre caused maximum increase in growth stem and root nodules production and nutrient uptake in *Sesbania rostrata* when compared with other treatments.
Sharma and Minhas (1973) stated while keeping in view the high potash removals and depleting K reserves of the soils and the crop yield are likely to be affected in the years to come even under NPK + FYM treatments.

Bharadwaj and Tyagi (1994) reported that application of potassium was quite responsive while nitrogen and phosphorus are also applied in rice-wheat-cow pea sequence.

Sharma and Ramana (1996) stated that applied nitrogen at 80 kg/ha and potassium at 33 kg/ha increase the yield of sorghum under rainfed condition in alfisols.

Pasricha and Randhawa (1973) observed maximum dry matter yield in crops after the application of sulphur @ 60 ppm.

Nad and Goswami (1983) found enhanced dry matter yield of with the application of sulphur.

Singh et al. (1988) reported that application of 30 to 75 kg sulphur per hectare increased the dry matter accumulation by plants. The optimum rate of sulphur application was @ 45 kg/ha in field pea.

Kasturikrishna and Ahlawat (1999) recorded that combined application of 40 kg S/ha and 5 kg Zinc Sulphate per hectare increased dry matter accumulation in field pea.

Singh et al. (1999) reported that significantly increase in dry matter of lentil with the application of S up to 40 kg/ha.

Gupta et al. (2001) reported that application of 30 kg sulphur/hectare increased the dry matter content in green gram.
Rao and Das (1967) recorded higher yield in leguminous crop with the use of sulphur.

Dube and Mishra (1970) reported that application of S @ 40 kg/ha significantly increased the grain and straw yields of field pea.

Singh (1970) reported about 100 and 50% increase in grain yield of pea in calcareous soil of Rajasthan with application of elemental sulphur, @ 250 kg/ha.

Aulakh et al. (1977) found the 147 and 127 percent increase in yield of chickpea and lentil, respectively with application of 40 kg sulphur per hectare.

Aulakh and Pasricha (1979) observed in trial that the yield of lentil crop increase with successive level of applied sulphur from 0 to 40 kg/ha. There was 47% enhanced grain yield of lentil due to application of 40 kg S/ha.

Lal and Jaiswal (1979) observed 23% increase in seed yield of black gram with the application of 30 kg s per ha as gypsum.

Tandon (1986) indicating that the response of sulphur applied on chickpea reported that the response of per kg sulphur was 7.6 kg grain.

Rajput and Pandey (2004) indicated that soil application of Rhizobium and PSB with FYM increased seed yield of pea by 20.5 and 23.5% higher than NPK at 50%, while seed treatment increased seed yield by only 5.6 and 11.5%, respectively. Biofertilizers mixed with FYM and NPK at 50% of the recommended rate was equivalent in effectiveness compared to NPK at 100%.
Singh et al. (2005) reported that effects of some integrated nutrient management (INM) modules on yield and yield attributes (pods/plant, pod weight, pod length, number of grains/pod, fresh weight/plant, fresh root weight/plant, nodule number and weight/plant) of 3 garden pea genotypes (Arkel, Azad Pea 1 had Azad Pea 3) during the Rabi season of 2002-03 and 2003-04 in Varanasi, Uttar Pradesh, India. The treatments comprised 0 kg NPK/ha, farmyard manure at 5 t/ha, pressmud (PM) at 5 t/ha, PM at 5 t/ha + phosphorus solubilizing microrganism (PSM) as seed treatment, PM at 5 t/ha + Rhizobium as seed treatment + PSM at 5 kg/ha as soil application, 30 : 60 : 80 kg NPK/ha, 0:60:80 kg NPK/ha+PM at 2 t/ha, and 30:60:80 kg NPK/ha+PM at 2 t/ha. Significant differential response in the potential yield of vegetable pea and seed grain was observed with the variation of genotypes and level of applied nutrients in INM modules. Azad P-1 and 10-15% higher yield potential over Azad P-3 and 25-30% over Arkel under the tested INM modules. The variation of N:P:K; N:S and N:P:K:S ratios in the treatment modules significantly influenced the variation of the yield attributes, yield and root nodulation activities. The application of S in the form of PM and the balance of N:S ratio significantly enhanced the yield and nodulation of the crop.

Datt et al. (2003) reported that uptake and improvement in fertility status of the soil was observed with each increment in NPK fertilizer along with a constant level of FYM in vegetable pea.

Pachauri et al. (1988) stated that the NPK application schedule is outlined. The highest seed yield was obtained on plots receiving N : P₂O₅ : K₂O at 75 : 150 : 50 kg/ha.
Nirmal et al. (2006) reported that S supplementation through pressmud increased yield attributes in the 3 cultivars of vegetable pea. The combination of OM + PSB + Azo + Rhiz resulted in higher plant height, fresh root and root weight, fresh pod yield and seed yield than the other treatments. The same treatment resulted in the highest contents of ascorbic acid (30 mg/100 g), carbohydrates (55%), protein (23.8%), phosphorus (0.67%) and sulphur (0.39%) in the grain.

Kashturikrishna and Ahlawat (2000) reported that the application of 40 kg S/ha improved root and growth parameters and yield of field pea. The improvement in growth attributes was more pronounced with S application.

Nareen and Farid (2003) reported that the significantly highest yield and yield attributes of pea were recorded under N30P50K40S20M04B1 kg/ha followed by N30P50K40S20M0 B3N30P50N30P50K40S20M0 B3N30P50K40S20 M0 and N30 P50 K40 S20 treatments. Granulation (%), seedling length, dry weight of seedling and vigour index were also more when the crop was raised from these four treatments over control. Application of N30, P50, K40, S20 kg/ha would be economically profitable for enhancing growth parameters and yield of garden pea.

2.6 Effect of sequential cropping of groundnut on economics

Singh (2006) reported from CSAUAT, Kanpur that the groundnut-wheat-summer groundnut cropping system gave higher monetary return and benefit cost ratio by Rs. 44815.00 and 1:1.49, respectively.
Singh (2007) stated that the maximum net income obtained from maize-potato-summer groundnut closely followed by maize-field pea-summer groundnut from normal soil condition with the use their respective RDF.

Singh (2005) reported that the maximum net income of Rs. 69,390/ha obtained from maize-potato-summer groundnut. Maize-field pea-summer groundnut gave net profit of Rs. 68,464/ha. Under partially reclaimed soils, the cropping system of maize-mustard-summer groundnut gave net income of Rs. 53645/ha. These cropping systems have rapidly spread to the farmers fields and in future the cultivation of groundnut in summer season will achieve newer heights.