*Indian Journal of Agronomy* **62** (3): 280–286 (September 2017)

**Research Paper**

# Production potential and energy dynamics of efficient cropping systems under diverse nutrient management practices

**D.P. PACHARNE[1]**

*Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra 413 722*

Received : December 2016; Revised accepted : June 2017

## ABSTRACT

A field experiment was conducted to evaluate the production potential, their energetics and economics of efficient cropping systems under different nutrient management practices during 2011–12 and 2012–13. The treatments consisted of 3 cropping systems [groundnut (*Arachis hypogaea* L.)–onion (*Allium cepa* L.), groundnut–wheat [*Triticum aestivum* (L.) emend. Fiori & Paol.] and groundnut–chickpea (*Cicer arietinum* L.)] with 4 nutrient management treatments, viz. recommended dose of fertilizer, fertilizer dose as per soil test, fertilizer dose as per soil test crop response (STCR) equations and control as main-plot treatments, whereas 3 fertilizer levels, viz. RDF, 75% RDF and 50% RDF as sub-plots treatments. Among the cropping systems, groundnut–onion cropping system recorded significantly maximum groundnut equivalent yield (7.82 t/ha), production efficiency (35.1 kg/ha/day) and economic efficiency (₹842.4/ha/day) than rest of the cropping systems. However, groundnut–chickpea (0.82 t/ha) recorded significantly higher protein than groundnut–wheat but at par with groundnut–onion, while carbohydrates (5.41 t/ha) and fats (0.81 t/ha) were registered higher with groundnut–onion cropping system. Application of fertilizer as per STCR equation to preceding groundnut registered significantly higher protein (0.95 t/ha), carbohydrate (4.20 t/ha) and fat (0.88 t/ha) than control treatments. Similarly, groundnut–onion cropping system obtained significantly maximum net monetary returns (₹188.1×$10^3$/ha) and benefit: cost ratio (2.98), but groundnut–chickpea cropping system registered significantly higher energy output-input ratio (9.54), energy balance/unit input (8.85) and energy intensiveness (2.59 MJ/₹) on pooled mean. At the end of the 2 years cropping cycles, groundnut–onion cropping system found to be most efficient and suitable for obtaining the maximum productivity and monetary returns with application of fertilizer as per STCR equation.

***Key words :*** Cropping systems, Energetics, Economic efficiency, Economics, Nutrient management, Production efficiency

Indian agriculture is now facing many problems like raising or lowering of water table, nutrient imbalance, soil degradation, salinity, resurgence of pests and diseases, environmental pollution and decline in farm profit. The crop diversification may prove to be paramount importance in several farming situations to improve the productivity and profitability without deteriorating soil health for a sustainable agriculture (Jat *et al.,* 2011). It also affects the productivity and soil health (Singh *et al.,* 2010). Cropping systems with suitable legume, fodder, oilseed and vegetable may result in high crop productivity, energetics and economic returns. Groundnut is the premier oilseed crop of India, occupies an area of 6.7 million ha and contributes 7.3 million tonnes towards oilseed production (GoI, 2012). India stands first in area and second in production and fifth in productivity (995 kg/ha). The challenge of producing 58.56% million tonnes of oilseeds to meet the requirement of 1.13 billion Indian populations. A gap of about 33.82 million tonnes of oilseeds needs growth rate of 5.56%/annum in the production (Rathika *et al.,* 2009). Area under oilseeds is not likely to increase in the near future due to delay and uneven occurance of rainfall and increase soil hardness. Groundnut is an unpredictable legume, since its response to nutrient application is always not optimistic, excessive application of nitrogen often resulted in excessive vegetative growth, considering the availability of the major elements in the soil and quantum of losses due to leaching or fixation of the individual elements. The review is aimed to have better understanding of different cropping system with inclusion of legume and different nutrient management treatments like recom-

[1]**Corresponding author's Email:** pacharne.dattatray@rediffmail.com

[1]Assistant Professor, Cotton Improvement Project, Mahatma Phule Krishi, Vidyapeeth, Rahuri, Maharashtra, 413 722

mended dose of fertilizer, fertilizer as per soil test and application of fertilizer as per STCR equation (yield target), which can be helpful for increasing the production of rainy season (*kharif*) groundnut and their residual effects on succeeding crops. It also increases the production potential, economics, energetics and sustainability of cropping systems. Therefore, an investigation was undertaken to find out efficient cropping systems and their energetics under different nutrient management.

## MATERIALS AND METHODS

A field experiment was conducted during 2011–12 to 2012–13 at Post-graduate Institute, Research Farm, Mahatma Phule Krishi Vidyapeeth, Rahuri (19° 48' N and 74° 32' E and 495 meter above mean sea-level). The average maximum and minimum atmospheric temperatures were 32.4°C and 15.5°C respectively. The average relative humidity was 62% in morning and 42.5% in the evening. Rainfall received during 2011–12 and 2012–13 was 527.8 and 424.0 mm respectively. The soil of the experimental site is sandy clay loam in texture (clay- 44.45%, silt- 33.20% and sand- 21.42%) having *p*H 8.2 and electric conductivity (EC) 0.29 dS/m and organic carbon 0.54% in top of 15 cm soil. Soil was low in available nitrogen (172.1 kg/ha), medium in phosphorus (18.0 kg/ha) and high in available potassium 427.0 kg/ha), moderate in Fe (6.89 µg/g), Mn (9.51 µg/g), Zn (0.62 µg/g) and Cu (3.41 µg/g). The field capacity, bulk density and permanent wilting point of the surface (0–15 cm) soil were 32.2% on volume basis, 1.32 Mg/m$^3$ and 16.2% respectively.

The experiment was laid out in randomized block design during rainy (*kharif*) season with 9 replications and strip-plot design in winter (*rabi*) season with 3 replications. The treatment tested include 3 cropping systems, viz. groundnut–onion, groundnut–wheat and groundnut–chickpea with 4 nutrient management practices, viz. recommended dose of fertilizer, fertilizer dose as per soil test, fertilizer dose as per STCR equations (2.5 t/ha of yield target) and control as main-plot treatment, whereas 3 fertilizer levels, viz. RDF, 75% RDF and 50% RDF as sub-plots treatments. The yield target equation was used for rainy season (*kharif*) groundnut as prescribed by Ramamoorthy *et al.,* (1967). Targeted yield equations for FN (kg/ha) = 4.16 T – 0.37 SN; $FP_2O_5$ (kg/ha) = 4.96 T – 4.36 SP; $FK_2O$ (kg/ha) = 3.14 T – 0.16 SK; Where, FN, $FP_2O_5$ and $FK_2O$ = Fertilizer in kg/ha; 'T' = Target yield (q/ha), SN = Soil available nitrogen (kg/ha), SP = Soil available phosphorus (kg/ha), SK = Soil available potassium (kg/ha). Groundnut was sown in third week of June and harvested at second week of October. The winter crops, viz. onion, durum wheat and chickpea were sown in second week of November and harvested in third and fourth week of March during both the years. The intercultural operations and plant protection measures were carried out as per the recommendations of respective crops. The economic yield of the component crops was taken into account over the years and then expressed as productivity (t/ha) of different cropping systems. The cost of cultivation was calculated by taking into account the prevailing prices of inputs. To compare different crop systems, the yields of all crops were converted into groundnut equivalents (GEs) on market price basis. Production efficiency in terms of kg/ha/day was worked out by total economic yield in terms of PE in a crop rotation divided by total duration of crops in a system (Tomar and Tiwari, 1990). Economic efficiency in terms of ₹/ha/day was worked out by dividing the net returns of the system by total duration of crops in an agricultural year (Patil *et al.,* 1995). Land utilization index was calculated by dividing total duration of respective crops with 365 days (Tomar and Tiwari, 1990). Net returns were the difference between the gross returns and total cost of cultivation of the component crops. Benefit: cost ratio (Returns/₹ invested) of a system was expressed as net returns/₹ spent. The input and output energies were calculated by energy conversion factors (Table 2) for inputs like labour, fuel, fertilizers, seeds, machineries, pesticides and irrigations etc. used in the respective crop system (Mittal and Dhawan, 1988; Devasenpathy *et al.,* 2009). System net energy returns was calculated by deducting total energy inputs involved in all crops from total energy output from the system. Energy output- input ratio was worked out by energy output divided by energy input. Energy balance per unit input was calculated by system net energy returns divided by total system energy inputs. Energy intensiveness was worked out by dividing energy output by cost of cultivation in-

**Table 1.** Agronomic practices followed for the different crops and values of energetic/100 g edible portion of the crop.

| Crop | Variety | Spacing | NPK (Kg/ha) | Number of irrigations | Protein (%) | Carbohydrate (%) | Fat (%) |
|---|---|---|---|---|---|---|---|
| Groundnut | 'JL 501' | 30 cm × 10 cm | 25–50–00 | 3 | 25.09 | 26.67 | 43.71 |
| Onion | 'N 2-4-1' | 15 cm ×10 cm | 100–50–50 | 5 | 1.01 | 11.3 | 0.7 |
| Wheat | 'Trimbak' | 22.5 cm line | 120–60–40 | 5 | 9.51 | 73.86 | 1.61 |
| Chickpea | 'Digvijay' | 30 cm × 10 cm | 25–50–00 | 3 | 22.39 | 53.81 | 1.15 |

**Table 2.** Energy conversion factors used in study

| Power source | Unit | Equivalent energy (MJ) |
|---|---|---|
| *Human labour* | | |
| Adult man | Man hour | 1.96 |
| Adult woman | Woman hour | 1.57 |
| *Animal labour* | | |
| Bullock medium | Pair hour | 10.10 |
| Machinery | | |
| Electric motor | kg | 64.80 |
| Self propelled machine | kg | 68.40 |
| Seed | kg | 62.70 |
| Wood | kg | 30.80 |
| *Chemical fertilizer* | | |
| Nitrogen | kg | 60.60 |
| $P_2O_5$ | kg | 11.10 |
| $K_2O$ | kg | 6.70 |
| Chemical | kg | 120.00 |
| Farm yard manure (dry) | kg | 0.30 |
| Diesel | Litre | 56.31 |
| Electricity (1.7630 kw/ h) | Kw/ha | 11.93 |
| *Seed/output* | | |
| Wheat | (dry) kg | 14.5 |
| Chickpea | (dry) kg | 15.1 |
| Oilseeds | (dry) kg | 25.0 |
| Onion | (dry) kg | 0.06 |
| *Byproducts* | | |
| Fodder | (dry) kg | 18.0 |
| Straw | (dry) kg | 12.5 |
| Stalk | (dry) kg | 18.0 |
| Dung | (dry) kg | 18.0 |
| *Fuel wood* | | |
| Hard | (dry) kg | 20.70 |
| Soft | (dry) kg | 18.90 |
| Kerosene | Litre | 41.30 |

Source, Panesar B.S. and A.B. Bhatnagar, 1994. Energy norms for inputs and outputs of agriculture sector. USG Publication Ludhiana.

curred in crop production. Statistical analysis of the data was carried out by using standard analysis of variance.

## RESULTS AND DISCUSSION

### *Yield of groundnut*

The significantly higher dry pod yield (2.36 t/ha) and protein content in rainy season (*kharif*) groundnut was recorded with the application of fertilizer as per the soil test crop response (STCR) equation (40, 50 and 20 kg NPK/ha). The yield target of 2.5 t/ha was achieved by STCR equation with less than 10% variation (–5.8%). The fertilizer dose as per soil test was found second best treatment of 1.93 t/ha (Table 3). Balanced nutrition also increases the chlorophyll content in leaves, which increases the photosynthetic rate and translocation of photosynthetic towards reproductive parts i.e. pods. Similarly, the groundnut being a legume crop having more nitrate reductase activities in root which is beneficial for peg formation and pod development stage (Ghosh *et al.,* 2003). Similar findings were reported by Dudhatra *et al*. (2002) and Varalakshmi *et al*. (2005).

### *Yield of winter season crops*

In onion, application of fertilizer as per STCR equation to preceeding crop rainy season (*kharif*) groundnut registered maximum and significantly higher bulb yield (59.8 t/ha) and it was 9.75% higher than recommended dose of fertilizer. Application of recommended dose of fertilizer (RDF: 100:50:50 kg NPK/ha) to succeeding onion crop preceded by groundnut registered significantly higher bulb yield (48.9 t/ha) and it was 4.46% higher than 75% RDF and 16.65% higher than 50% RDF (Table 3). This might be owing to residual effect of preceding crop maintaining soil organic matter, major and micronutrients, which increases the uptake of these nutrients and accelerating the physiological activities in crop for improving growth attributes. Similarly, it also increased the translocation of photosynthates towards onion bulb, which resulted in increasing the weight of bulb. These results are in conformity with those reported by Reddy and Suresh (2009) and Jat *et al.* (2011).

In wheat, application of fertilizer as per STCR equation to preceding crop groundnut registered significantly maximum grain yield of wheat (4.26 t/ha) and it was 8.28% higher than recommended dose of fertilizer on pooled mean basis (Table 3). Application of RDF (120:60:40 kg NPK/ha) to wheat recorded significantly maximum grain yield (3.64 t/ha) and it was 14.86% higher than reduced level of fertilizer, i.e. 50% RDF but at par with 75% RDF (Table 3). This indicate that growing of wheat crop after *kharif* groundnut saves 25% RDF because of balance nutrition to *kharif* groundnut through STCR equation, which created favourable environment in the root rhizosphere of wheat crop to absorb more nutrients and moisture by improving the nutrient-use efficiency. These results are corroborated with findings of Verma *et al*. (2005), Ramesh *et al*. (2009), Mubarak and Singh (2011) and Hashim *et al.* (2015)

In chickpea, fertilizer management as per STCR equation registered significantly higher grain yield (2.89 t/ha), which was 11.38% higher than recommended dose of fertilizer (Table 3). Application of RDF (25:50:00 kg NPK/ha) to chickpea crop exhibited significantly maximum growth and grain yield of chickpea and recorded significantly higher grain yield of 2.65 t/ha and at par with 75% RDF (Table 3). This indicates that, 25% of fertilizer dose was saved, when chickpea grown after *kharif* groundnut. These results are in accordance with Rao and Shaktawat (2002), Ramesh *et al*. (2009) and Singh *et al.* (2010).

### Groundnut equivalent yield

Among the cropping systems, groundnut–onion cropping system recorded significantly maximum groundnut equivalent yield of 7.82 t/ha and it was 138.89 % higher than groundnut–wheat system and 92.68% higher than groundnut–chickpea system. The nutrient management as per STCR equation proved it's superiority by recording maximum groundnut equivalent yield of 6.69 t/ha and it was 19.25% higher than that of recommended dose of fertilizer (Table 3). Application of RDF to succeeding winter season (*rabi*) crops preceded by *kharif* groundnut registered significantly higher groundnut equivalent yield than 50% RDF and at par with 75% RDF.

### Production efficiency

Among the cropping systems, groundnut–onion cropping system registered significantly higher production efficiency of 35.1 kg/ha/day than groundnut–wheat and groundnut–chickpea cropping systems. The nutrient management treatments as per STCR equation registered significantly higher production efficiency of 30.2 kg/ha/day and it was 17.2% higher than recommended dose of fertilizer. Application of RDF to succeeding crop during *rabi* season registered significantly higher production efficiency than 50% RDF and at par with 75% RDF on pooled mean (Table 4).

### Economic efficiency

The groundnut–onion cropping system recorded significantly higher economic efficiency of ₹842.4/ha/day than groundnut–wheat and groundnut–chickpea cropping systems. Application of fertilizer as per STCR equation to *kharif* groundnut recorded significantly higher economic efficiency of ₹713.3/ha/day than rest of the nutrient management and control treatment. The economic efficiency of different cropping systems was also influenced by different fertilizer levels to succeeding crops. Application of RDF to succeeding crop during *rabi* season recorded significantly higher economic efficiency than 50% RDF level and at par with 75% RDF (Table 4). This is because of higher yield and biomass production with higher level of fertilizer.

### Energetics

Evaluation of different cropping systems through energetics is appreciated these days as it is more stable and meaningful and it indicates the energy yield from the system which does not fluctuates with the market prices since it is based on nutritional value of the system. Unlike, groundnut-equivalent yields, energetics revealed different pattern, where in protein yields were significantly higher in groundnut–chickpea (0.82 t/ha) than groundnut–wheat but at par with groundnut–onion because of higher protein

**Table 3.** Yield and groundnut equivalent yield, protein, carbohydrates and fat yield as influenced by different treatment (pooled mean of 2 years)

| Treatment | Groundnut (t/ha) | Onion (t/ha) | Wheat (t/ha) | Chickpea (t/ha) | Groundnut equivalent yield (t/ha) | Protein (t/ha) | Carbohydrate (t/ha) | Fat (t/ha) |
|---|---|---|---|---|---|---|---|---|
| *Cropping system* | | | | | | | | |
| Groundnut–onion | | - | - | - | 7.82 | 0.74 | 5.41 | 0.81 |
| Groundnut–wheat | | - | - | - | 3.27 | 0.61 | 2.79 | 0.55 |
| Groundnut–chickpea | | - | - | - | 4.06 | 0.82 | 1.59 | 0.55 |
| SEm± | | - | - | - | 0.06 | 0.06 | 0.67 | 0.13 |
| CD (P=0.05) | | - | - | - | 0.19 | 0.17 | 1.90 | N.S. |
| *Nutrient management* | | | | | | | | |
| Recommended dose of fertilizer | 1.71 | 54.5 | 3.94 | 2.59 | 5.61 | 0.78 | 3.73 | 0.65 |
| Fertilizer dose as per soil test | 1.93 | 55.7 | 4.08 | 2.69 | 5.93 | 0.83 | 3.87 | 0.73 |
| Fertilizer dose as per STCR eq$^n$ (25 t/ha) | 2.36 | 59.8 | 4.26 | 2.89 | 6.69 | 0.95 | 4.20 | 0.88 |
| Control (No Fertilizers) | 0.73 | 13.5 | 1.31 | 1.35 | 1.97 | 0.33 | 1.25 | 0.29 |
| SEm± | 0.05 | 0.6 | 0.041 | 0.05 | 0.08 | 0.04 | 0.78 | 0.15 |
| CD (P=0.05) | 0.14 | 2.7 | 0.14 | 0.20 | 0.24 | 0.13 | 2.20 | 0.43 |
| *Fertilizer level* | | | | | | | | |
| RDF | | 48.9 | 3.64 | 2.64 | 5.24 | 0.75 | 3.46 | 0.62 |
| 75% of RDF | | 46.8 | 3.48 | 2.43 | 5.18 | 0.74 | 3.32 | 0.65 |
| 50% of RDF | | 41.9 | 3.17 | 2.07 | 4.73 | 0.68 | 3.01 | 0.63 |
| SEm± | | 0.5 | 0.07 | 0.04 | 0.05 | 0.03 | 0.67 | 0.13 |
| CD (P=0.05) | | 1.8 | 0.23 | 0.12 | 0.14 | 0.10 | NS | N.S. |

RDF, Recommended dose of fertilizers

content in groundnut and chickpea grains as compared to other crop study (Table 1, 2 and 3), while carbohydrates (5.41 t/ha) and fats (0.81 t/ha) were registered higher with groundnut–onion cropping system with higher crop yields with respective crops. These results are in conformity with the results of Jain *et al*. (2015).

The groundnut–chickpea cropping system was registered significantly higher energy output-input ratio (9.54), energy balance/unit input (8.85) and energy intensiveness (2.59 MJ/₹). The groundnut–chickpea cropping system was recorded maximum yield with minimum input energy than groundnut–onion and groundnut–wheat cropping system. Application of fertilizer as per STCR equation to preceding *kharif* groundnut recorded significantly higher energy output, system net energy returns and energy intensiveness than rest of all the treatment combinations. The application of recommended dose of fertilizer to succeeding crops registered significantly higher system net energy returns, energy output-input ratio and energy intensiveness than rest of the treatment combinations (Table 5). Both the crops (groundnut and chickpea) fixes atmospheric nitrogen, thereby reduces the input energy required for obtaining higher yield resulting in higher output-input ratio and system net energy returns. Similar results recorded by Devasenapathy *et al.,* (2009) and Honnali and Chittapur, 2014).

### *Economics*

Among the cropping systems, groundnut–onion cropping system obtained significantly higher net monetary returns (₹188.1×$10^3$/ha) and benefit: cost ratio (2.98) than groundnut–wheat and groundnut–chickpea cropping systems. The groundnut–chickpea cropping system was second in rank with respect to net monetary returns. Application of fertilizer as per STCR equation to *kharif* groundnut obtained significantly maximum net monetary returns (₹158.0×$10^3$/ha) and benefit: cost ratio (2.90) than rest of the nutrient management treatments. Application of RDF to succeeding crop during *rabi* season obtained significantly higher gross net monetary returns (₹109.8×$10^3$/ha) and benefit: cost ratio 2.38 than 50% RDF and at par with 75% RDF in respect of gross and net monetary returns and benefit: cost ratio (Table 4).

Thus it can be concluded that, groundnut–onion cropping system found to be most efficient and suitable for achieved maximum productivity and monetary returns with application of fertilizer as per soil test crop response (STCR) equation.

## REFERENCES

Devasenapathy, P., Senthilkumar, G. and Shanmugam, P.M. 2009. Energy management in crop production. *Indian Journal of Agronomy* **54**(1): 80–90.

**Table 4.** Production efficiency, economic efficiency and economics as influenced by different treatment (pooled mean of 2 years)

| Treatment | Production efficiency (kg/ha/day) | Economic efficiency (₹/ha/day) | Cost of cultivation (×$10^3$₹/ha) | Net monetary returns (×$10^3$₹/ha) | Benefit: cost ratio |
|---|---|---|---|---|---|
| *Cropping system* | | | | | |
| Groundnut–onion | 35.0 | 842.4 | 95.1 | 188.0 | 2.98 |
| Groundnut–wheat | 15.0 | 209.3 | 72.1 | 46.0 | 1.64 |
| Groundnut–chickpea | 19.2 | 363.4 | 69.0 | 77.2 | 2.11 |
| SEm± | 0.15 | 5.95 | - | 1.25 | - |
| CD (P=0.05) | 0.45 | 17.45 | - | 3.67 | - |
| *Nutrient management* | | | | | |
| Recommended dose of fertilizer | 25.8 | 552.3 | 82.2 | 120.5 | 2.47 |
| Fertilizer dose as per soil test | 27.0 | 598.1 | 82.8 | 131.5 | 2.59 |
| Fertilizer dose as per STCR $eq^n$ (25 t/ha) | 30.2 | 713.3 | 83.2 | 158.0 | 2.90 |
| Control (No Fertilizers) | 9.3 | 23.24 | 66.1 | 4.9 | 1.07 |
| SEm± | 0.18 | 6.87 | - | 14.4 | - |
| CD (P=0.05) | 0.53 | 20.15 | - | 42.4 | - |
| *Fertilizer level* | | | | | |
| RDF | 24.1 | 499.7 | 79.5 | 109.8 | 2.38 |
| 75% of RDF | 23.5 | 492.3 | 78.7 | 108.3 | 2.37 |
| 50% of RDF | 21.6 | 423.2 | 77.8 | 93.1 | 2.20 |
| SEm± | 0.21 | 3.76 | | 1.28 | |
| CD (P=0.05) | 0.60 | 10.69 | | 3.85 | |

Market price: 2011–12, Groundnut 34,500₹/t; Onion 3,600₹/t; Wheat 14,000₹/t; Chickpea 33,000₹/t; 2012–13, Groundnut 37500₹/t; Onion 6000₹/t; Wheat 18,000₹/t; Chickpea 36,000₹/t

**Table 5.** Energy indices of different cropping systems as influenced by different nutrient managements (pooled mean of 2 years)

| Treatment | Input energy (× $10^3$ MJ/ha) | Output energy (× $10^3$ MJ/ha) | System net energy returns (× $10^3$ MJ/ha) | Energy output-input ratio | Energy balance per unit input | Energy intensiveness (MJ/₹) |
|---|---|---|---|---|---|---|
| *Cropping system* | | | | | | |
| Groundnut–onion | 23.5 | 158.4 | 134.9 | 6.72 | 5.72 | 1.66 |
| Groundnut–wheat | 20.9 | 183.2 | 162.3 | 8.74 | 7.74 | 2.54 |
| Groundnut–chickpea | 18.1 | 179.2 | 161.1 | 9.54 | 8.85 | 2.59 |
| SEm± | 0.12 | 1.09 | 1.09 | 0.05 | 0.05 | 0.03 |
| CD (P=0.05) | 0.36 | 3.21 | 3.22 | 0.16 | 0.16 | 0.09 |
| *Nutrient management* | | | | | | |
| Recommended dose of fertilizer | 21.0 | 185.1 | 164.1 | 8.81 | 7.81 | 2.25 |
| Fertilizer dose as per soil test | 22.3 | 202.3 | 180.0 | 9.06 | 8.07 | 2.44 |
| Fertilizer dose as per STCR eq$^n$ (25 t/ha) | 25.7 | 233.8 | 208.1 | 9.09 | 8.10 | 2.81 |
| Control (No Fertilizers) | 14.5 | 73.4 | 58.8 | 5.03 | 4.05 | 1.11 |
| SEm± | 0.14 | 1.26 | 1.26 | 0.06 | 0.06 | 0.04 |
| CD (P=0.05) | 0.42 | 3.71 | 3.71 | 0.18 | 0.18 | 0.12 |
| *Fertilizer level* | | | | | | |
| RDF | 22.0 | 186.8 | 166.0 | 8.50 | 7.56 | 2.35 |
| 75% of RDF | 20.9 | 172.3 | 154.8 | 8.23 | 7.40 | 2.19 |
| 50% of RDF | 19.8 | 153.6 | 137.4 | 7.74 | 6.92 | 1.97 |
| SEm± | 0.08 | 1.09 | 1.09 | 0.06 | 0.06 | 0.04 |
| CD (P=0.05) | 0.22 | 3.11 | 3.12 | 0.17 | 0.18 | 0.12 |

RDF, Recommended dose of fertilizers


Dudhatra, M.G., Vaghani, M.N., Kachot, N.A. and Asodaria, K.B. 2002. Integrated input management in groundnut (*Arachis hypogaea*)–wheat (*Triticum aestivium*) cropping system. *Indian Journal of Agronomy* **47**(4): 482–486.

Ghosh, P.K., Dayal, D., Mandal, K.G., Wanjari, R.H. and Hati, K.M. 2003. Optimization of fertilizer schedules in fallow and groundnut-based cropping systems and assessment of system sustainability. *Field Crops Research* **80**: 83–98.

GoI, 2012. All India estimates of food grain production, State of Indian Agriculture 2012–13, Government of India, New Delhi. pp. 193–197.

Hashim, Moammad., Dhar, Shiva., Vyas, A.K., Pramesh, V. and Kumar, Bipin. 2015. Integrated nutrient management in maize (*Zea mays*)–wheat (*Triticum aestivum*) cropping system. *Indian Journal of Agronomy* **60**(3): 352–359.

Honnali, S.N. and Chhitapur, B.M. 2014. Efficient cropping systems and their energetics for sustainable irrigated tropical systems. *Indian Journal of Agronomy* **59**(4): 556–560.

Jain, N.K., Singh, Hari, Dashora, L.N. and Mundra, S.L. 2015. Maize (*Zea mays*)–wheat (*Triticum aestivum*)-cropping system: Intensification through introduction of pulses. *Indian Journal of Agronomy* **60**(3): 347–351.

Jat, R.S., Dayal Devi, Meena, H.N., Singh, Virendra and Gedia, M.V. 2011. Long-term effect of nutrient management and rainfall on pod yield of groundnut (*Arachis hypogea*) in groundnut-based cropping systems. *Indian Journal of Agronomy* **56**(2): 145–149.

Mittal, J.P. and Dhawan, J.C. 1988. Research Manual on Energy Requirements in Agricultural Sector. AICRP on Energy Requirements in Agricultural Sector, PAU, Ludhiana, pp. 20–23.

Mubarak, T. and Singh, K.N. 2011. Nutrient management and productivity of wheat (*Triticum aestivum*)-based cropping systems in temperate zone. *Indian Journal of Agronomy* **56**(3): 176–181.

Patil, E.N., Jawale, S.M. and Mahajan, M.S. 1995. Production potential, economics and fertility status as influenced by wheat (*Triticum aestivum*)-based cropping systems. *Indian Journal of Agronomy* **40**(4): 544–648.

Ramamoorthy, K., Radhamani, S., Mohamed Amanullah, M. and Subbiah, P. 2009. Role of food legumes in organic farming. *Green Farming* **2**(12): 830–834.

Ramesh, P. Panwar, N.R., Singh A.B. and Ramana, S. 2009. Production potential, nutrients uptake, soils fertility and economics of soybean (*Glycine max*)-based cropping systems under organic chemical and integrated nutrient management practices. *Indian Journal of Agronomy* **54**(3): 278–283.

Rao, S.S. and Shaktawat M.S. 2002. Residual effect of organic manure, phosphorus and gypsum application in preceding groundnut (*Arachis hypogaea*) on soil fertility and productivity of Indian mustard (*Brassica juncea*) *Indian Journal of Agronomy* **47**(4): 487–494.

Rathika, S., Ramah, K. and Ramesh, T. 2009. Integrated nutrient management in oilseeds. *Green Farming* **2**(8): 551–553.

Reddy, B.N. and Suresh, G. 2009. Crop diversification with oilseed crops for maximizing productivity, profitability and resource conservation. *Indian Journal of Agronomy* **54**(2): 206–214.

Singh R.A., Singh, I.P. and Haider, E. 2010. Balanced nutrition of chickpea in groundnut (*Arachis hypogea*)–chickpea (*Cicer arietinum*) cropping system. *International Journal of Agriculture Science* **6**(2): 590–591.

Tomar, S.S. and Tiwari, A.S. 1990. Production potential and economics of different cropping sequences. *Indian Journal of Agronomy* **35**(1–2): 30–35.

Varalakshmi, L.R., Srinivasamurthy, C.A. and Bhaskar, S. 2005. Effect of integrated use of organic manures and inorganic fertilizers on organic carbon, available N, P and K in sustaining productivity of groundnut (*Arachis hypogaea*)–fingermillet (*Eleusine coracana*) cropping system. *Journal of the Indian Society of Soil Science* **53** (3): 315–318.

Verma, A., Nepalia, V. and Kanthaliya, P.C. 2005. Effect of continues cropping and fertilization on crop yields and nutrient status of a *Typic Haplustept*. *Journal of the Indian Society of Soil Science* **53**(3): 365–368.