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Influence of tillage and fertilizer management practices on productivity and resource use efficiency of groundnut (*Arachis hypogaea*) in Thar Desert of Rajasthan

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ABSTRACT

Conventional tillage practices in Thar Desert of Rajasthan are posing a serious threat of natural resource degradation due to soil erosion induced by high temperature and winds. A 2-year study was conducted to explore the efficient tillage and nutrient management practices evaluate the effects of these practices on groundnut crop performance and resource use efficiency. It consisted 18 treatment combinations; 3 tillage practices, viz. T_1 - minimum tillage, T_2 - deep tillage, and T_3 - conventional tillage main plots; and six fertilizer management practices, viz. F_0 - no fertilization, F_1 -recommended dose of NK fertilizer, F_2 - recommended dose of NPK fertilizer (RDF), F_3 - RDF + PSB @2.5 kg/ha, F_4 - F_3+ AMF @2 kg/ha, and F_5 - F_3+ AMF @4 kg/ha as sub plots. The highest LAI, crop growth rate and relative growth rate was recorded with deep tillage (T_2) and F_5 treatment combination. Deep tillage (T_2) produced significant at par yields (pod and haulm) with conventional tillage (2981 and 4878 kg/ha). Higher water use efficiency of 4.72% and 13.25% were recorded with T_3 compared to T_2 and T_1, respectively. Fertilizer management practices F_5 and F_4 recorded significantly at par and higher yields (pod, kernel, haulm and biological) compared to other combinations. The F_5 treatment notable increased 16.7% and 90.2% water and nutrient use efficiency over RDF (6.69 kg/ha mm and 14.95 kg/kg), respectively. In Thar Desert, deep tillage along with chemical fertilizers and bio-inoculants found best management practices in terms of productivity and resource use efficiency.

Keywords: Fertilizer management, Groundnut, Resource use efficiencies, Tillage, Yield

Groundnut (*Arachis hypogaea* L.) is world's fourth most important source of edible oil and third most important source of vegetable protein. India is the largest producer of oilseeds in the world and oilseed sector occupies an important position in the agricultural economy of the country (Rai *et al*. 2016). Appropriate tillage operations in conjunction with chemical and bio-fertilizers are required to sustain the soil and crop productivity in the defined agro-ecosystems. The basic aim of tillage in crop production is to provide favorable physical conditions for seed germination and plant growth (Jabro *et al*. 2011). In the present scenario minimum tillage in different cropping systems is the demand of time due to steep rising in diesel prices. For row-crop production, no-tillage methods became much more feasible in the late 1960s as herbicides became available to replace tillage for controlling unwanted vegetation.

Bio-fertilizers containing useful micro-organisms are known to supplement the chemical fertilizers and are able to enhance the plant growth by increasing the availability and supply of plant nutrients. Though, bio-fertilizer in isolation cannot give the spectacular results in providing and making nutrient availability to crops plants. Combined application of bio-inoculants gave better results than single inoculation which suggested that bio-inoculants worked synergistically with each other (Kumar *et al*. 2018). Mycorrhizal application can effectively reduce the quantitative use of chemical fertilizer input especially of phosphorus (Ortas 2012). Integration of AMF with other bio-fertilizers including Rhizobium and PSB may help in crop growth and development.

The studies on combined effect of tillage and bio-inoculants on groundnut are lacking in the arid and fragile ecosystem of Thar Desert. Therefore, the present investigation was carried out with the hypothesis that tillage and fertilizer management can improve the growth, productivity and resource use under groundnut crop in arid conditions of Rajasthan.

MATERIALS AND METHODS

A field trial on groundnut was carried out at Instructional Farm, College of Agriculture, Bikaner, Rajasthan (73.22°E, 28.01°N and 234.7 m above mean sea level) during two

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consecutive *kharif* seasons of 2019 and 2020. The site falls under Agro-climatic zone XIV (Western Dry Region) of India as per National Planning Commission. The climate is characterized by hyper aridity with extremes of temperatures both in summer and winter seasons.

The average annual rainfall of Bikaner is about 274 mm, which is mostly received during the rainy season from July to September. During the experimental crop periods, maximum and minimum temperature were ranged between 23.0–42.3°C and 9.1–30.5°C in 2019 and between 27.0–42.3°C and 6.9–29.3°C in 2020. The relative humidity of the locality fluctuated amid of 32.4–93.6% during 2019 and 15.6–88.4% during 2020. The total rainfall received was 241 mm in 14 rainy days and 157.9 mm in 12 rainy days during 2019 and 2020, respectively and respective evaporation from Class A open pan evaporimeter recorded was 199.1 mm and 183.9 mm. The soil was loamy sand in texture and having *p*H 8.4, low inorganic carbon (0.11%), medium in available phosphorus (18.9 kg/ha) and potash (260 kg/ha).

A total 18-treatment combinations were used in this study which comprised of three tillage practices in main plots, *viz.* T_1- minimum tillage (using tractor drawn rotavator), T_2- deep tillage (using tractor drawn disc plough followed by rotavator) and T_3- conventional tillage (using tractor drawn disc harrow followed by rotavator) and six fertilizer management practices as sub plots, viz. F_0-no fertilization (control), F_1- recommended dose of NK fertilizer, F_2- recommended dose of NPK @20:32:15 kg/ha (RDF), F_3- RDF + PSB @2.5 kg/ha, F_4- RDF + PSB @2.5 kg/ha + AMF @2 kg/ha and F_5- RDF + PSB @2.5 kg/ha + AMF @4 kg/ha. The experiment was laid out in a split-plot design with four replications. Disc harrow and plough was done before pre-sowing irrigation while rotavator was done at whapasa condition. The respective mixture of NPK fertilizers and bio-inoculants-PSB & AMF were applied as per the standard procedure.

Groundnut variety HNG-69 was sown @120 kg/ha seed rate with planting geometry of 30 cm × 10 cm and at 5–7 cm depth during the first week of June every year. The seed was treated with fungicide chlorthinidine @2 g/kg seed, imidachloprid (17.8 SL) @3 ml/kg seed and *rhizobium* spp. (FIR technique) before sowing. A common dose of well decomposed sheep manure @10 t/ha (0.50–0.52% N, 0.26–0.27% P_2O_5 and 0.56–0.59% K_2O) was incorporated into soil during final field preparation. Irrigations (each 40 mm) were given on appearance of moisture deficiency symptoms of the crop as and when need arose during crop growing periods.

Different growth parameters, viz. crop growth rate (CGR), relative growth rate (RGR), leaf area index (LAI) and membrane stability index (MSI) were determined by following the standard protocols. Water use efficiency (WUE) of different treatments was computed by dividing the economic yield (kg/ha) by irrigation water applied (mm) of respective treated plots. It was expressed in kg/ha mm (Ibragimov *et al*. 2011).

$$\text{WUE (kg/ha/mm)} = \frac{\text{Economic (kernel) yield (kg/ha)}}{\text{Irrigation water applied (mm)}}$$

Nutrient use efficiency may be defined as yield (produce) per unit fertilizer used or in terms of recovery of fertilizer applied. Nutrient-use efficiency (NUE) was computed with the formulae given below:

$$\begin{array}{l}\text{Nutrient use efficiency}\\ \text{(kg grain/kg nutrient)}\end{array} = \frac{\text{Pod yield (kg/ha) in treated plot - Pod yield in control plot}}{\text{Nutrient applied (kg/ha)}}$$

Crop growth parameters, resource use related data were recorded in time by following the standard protocols. The crop was harvested, dried, threshed, cleaned and weighed. In order to test the significance of variance in the experiment, the data so obtained from various treatment effects were subjected for analyses of statistical significance (ANOVA) as suggested by Panse and Sukhatme (1985). The critical differences were calculated to assess the significance of treatment means where, the F-test was found significant at 5 per cent level of significance.

RESULTS AND DISCUSSION

Crop growth parameters: The ancillary growth parameters, viz. CGR, LAI and MSI measured at growth stages between 40, 80 DAS and at harvest were significantly influenced by tillage and fertilizer management practices (Table 1). While tillage practices, viz. minimum (T_1), deep (T_2) and conventional (T_3) had not brought any significant variation with respect to relative growth rate (RGR) between 40–80 DAS and 80 DAS-harvest. Data showed further that deep tillage in groundnut produced significantly higher crop growth rate (0.084, 0.777 and 0.784 g/m^2/day) at growth stages between 0–40, 40–80 DAS and 80 DAS-harvest, respectively over minimum tillage and conventional tillage at 80 DAS-harvest also. Photosynthetic capacity of the plant is a function of leaf area development which could probably be due to increased assimilatory surface at all subsequent growth stages reported by Borkar and Dharanguttikar (2014) in groundnut. Whereas deep tillage practice in groundnut recorded significantly higher LAI and MSI values of leaves at all stages over minimum tillage and conventional tillage. Deep tillage (T_2) recorded 13.87, 7.57 and 7.19% higher LAI at 40, 80 DAS and at harvest compared to T_3, respectively. Also, T_3 increased the LAI at 40, 80 DAS and harvest by 19.13, 6.69 and 3.18%, respectively over T_1. Almost similar trend of MSI in groundnut at various stages was noticed by different tillage practices. Deep tillage in groundnut registered higher LAI and MSI at all stages over minimum tillage and conventional tillage (Table 1). This might be due to better soil pulverization resulting into better biological environment. Higher LAI is directly proportional to the photosynthetic activity which results into higher growth and development of the plant. Similar findings of tillage practices were reported by Parihar *et al*. (2012) and Usman *et al*. (2014) in pearl millet.

The fertilizer management practices in F_1, F_2 and F_3 were statistically at par in respect to crop growth rate at all growth stages however they registered significant superiority over F_0. The RDF + F_5 was found at par with F_3 and F_4 and had higher values of CGR, LAI and MSI at 40, 80 DAS over no fertilization application and F_1 and F_2 (Table 1). During early stage of growth (40 DAS) LAI was significantly influenced under all six treatments of fertilizer management however at 80 DAS, harvest F_3 was at par to F_2 and gave significantly higher LAI to the tune of 7.88 and 24.06%, respectively compared to F_1 and F_0.

The RGR values were found statistically at par in all six fertilizer treatments irrespective of crop growth stages. This might be due to increased leaf area that facilitated the more solar radiation interception (sun light) at enhanced rate thereby contributing towards more photosynthates production by crop plants leading to higher LAI (Aduloju *et al.* 2009). Greater LAI enhances further crop growth characters and yield attributes resulting into higher yield. These findings are in line with those earlier findings of Dutta *et al.* (2012). Lower MSI value at 40 and 80 DAS were noticed in F_0 in comparison to rest of the treatments which may be possibly due to less absorption of soil moisture by roots/rhizosphere under the former treatment.

Resource (water and nutrient) use efficiency: Results clearly showed that the highest water use efficiency (WUE) was recorded with conventional tillage (7.10 kg/ha mm), then deep tillage (6.84 kg/ha mm) and lowest with minimum tillage (6.33 kg/ha mm). Tillage practice affects the water use efficiency by modifying the hydrological properties of the soil and direct influencing root growth in the soil and indirectly affecting above ground canopy development of plants. Further tillage methods influence wettability, water extraction pattern and transport of water and solutes through its effect on soil structure, aggregation, total porosity and pore size distribution. The highest uptake of nutrients was observed under T_3 as it is directly proportional to the dry matter accumulation in plants and its content at cellular level. These results are substantiated by the findings of Zamir *et al.* (2012). Sharma *et al.* (2014) found that yearly deep ploughing resulted into 45.4% higher mean infiltration depth and 16.1% higher rain water use efficiency as compared to shallow ploughing (8.8 cm and 1.37 kg/ha mm) in a long term study on groundnut at Rajkot, Gujarat. Sinha (2015) observed highest water-use efficiency with deep tillage + two inter-culture operations over minimum tillage (without disc ploughing) by improving the physical conditions of soil in pearlmillet.

Highest water use efficiency (7.81 kg/ha mm) was recorded with F_5 which was at par to F_4 (7.70 kg/ha mm) and the lowest of 5.40 kg/ha mm under control (F_0) plot. However, the highest nutrient use efficiency in respect of N, P and K (50.08, 31.30 and 66.78 kg/kg) was recorded with F_5 closely followed by F_4 (46.89, 29.31 and 62.52 kg/kg) and decreased sharply in the order of $F_3 > F_2 > F_1 > F_0$ respectively. Maya *et al.* (2017) reported that combined inoculation of seed and soil with PSB + VAM significantly

Table 1 Effect of tillage and fertilizer management on physiological traits, water and nutrient use efficiency of groundnut

Treatment	CGR (g/m^2/day)			RGR (g/g/day)		Leaf area index			MSI (%)		Water use efficiency (kg/ha mm)	Nutrient use efficiency (kg/kg)
	0–40 DAS	40–80 DAS	80 DAS-harvest	40–80 DAS	80 DAS-harvest	40 DAS	80 DAS	At maturity	40 DAS	80 DAS		
Main plot: Tillage practices												
Minimum tillage (T_1)	0.079	0.724	0.713	25.18	6.882	1.15	3.59	2.83	30.09	30.92	6.33	-
Deep tillage (T_2)	0.084	0.777	0.780	25.28	7.012	1.56	4.12	3.13	33.08	35.01	6.84	-
Conventional tillage (T_3)	0.082	0.760	0.723	25.28	6.737	1.37	3.83	2.92	31.89	34.03	7.10	-
CD (P=0.05)	0.003	0.034	0.033	NS	NS	0.04	0.24	0.18	0.71	0.75	0.36	-
Sub plot: Fertilizer management												
Control (No fertilization) (F_0)	0.072	0.679	0.663	25.51	6.851	1.25	3.20	2.53	29.09	29.84	5.40	-
Recommended dose of NK fertilizer (F_1)	0.082	0.749	0.718	25.15	6.769	1.28	3.68	2.88	31.35	32.31	5.95	6.13
Recommended dose of NPK fertilizer (F_2)	0.083	0.757	0.734	25.17	6.822	1.34	3.91	2.94	31.83	33.44	6.69	7.86
RDF+PSB @ 2.5 kg/ha (F_3)	0.084	0.769	0.756	25.19	6.906	1.38	3.97	3.01	32.17	33.97	7.00	9.82
RDF+PSB @ 2.5 kg/ha +AMF @ 2 kg/ha (F_4)	0.085	0.783	0.773	25.22	6.925	1.43	4.07	3.13	32.74	35.05	7.70	14.00
RDF+PSB @ 2.5 kg/ha +AMF @ 4 kg/ha (F_5)	0.086	0.787	0.788	25.21	6.990	1.46	4.25	3.25	32.92	35.30	7.81	14.95
CD (P=0.05)	0.003	0.024	0.040	NS	NS	0.02	0.30	0.22	0.75	0.95	0.39	-

Note: NS : Non-significant, DAS : Days after sowing, RDF : Recommended dose of fertilizer, PSB : Phosphate solubilizing bacteria, AMF : Arbuscular mycorrhizal fungi increased the agronomic efficiency and apparent recovery of phosphorus. Kumar *et al*. (2018) in central India found synergistic relation with combined inoculation than single inoculation and recorded the higher yields under groundnut and sesame crop.

Pod and haulm yield: Different tillage practices influenced the pod and haulm yield of groundnut during both years and on pooled data basis (Fig 1, 2). The highest pod (2981 kg/ha) and haulm (4878 kg/ha) yield was obtained with T_3 then T_2 (2853, 4750 kg/ha) and the lowest with T_1 (2636, 4573 kg/ha). Both conventional (T_3) and deep tillage (T_2) were found at par and yielded significantly higher pod yield by 13.09% and 8.23% over minimum tillage (T_1). Similar yields were recorded with deep and conventional tillage during the year of study. The findings are in agreement with the results obtained by Chaudhary *et al*. (2015). Higher yields (pod and haulm) might be an outcome of increased dry matter accumulation per plant during growth stages (40, 80 DAS) till harvest of groundnut crop. This may be due to favorable environment in soil and inside the plant, which led to increased photosynthetic efficiency.

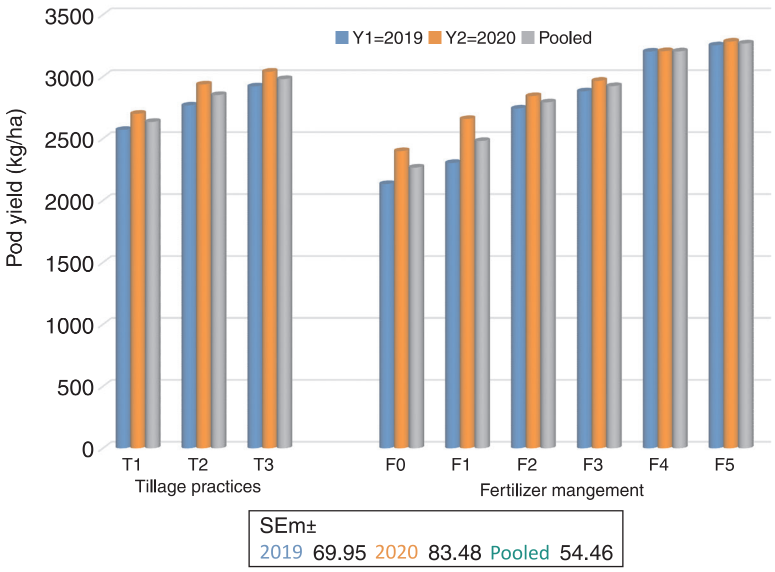

Fig 1 Effect of tillage and fertilizer management practices on pod yield (kg/ha) of groundnut.

Significantly highest pod (3268 kg/ha) and haulm (5248 kg/ha) yield of groundnut was recorded with F_5 while the lowest yields with no fertilization. The increased yields with F_3, F_4 and F_5 were resultant of balance nutrition and favorable soil rhizosphere environment through bio-inoculants (PSB+AMF) which ultimately led to profuse growth and development of plants and thereby resulted into better yields. The optimum dose of NPK fertilization (RDF) along with PSB + AMF (F_3, F_4 & F_5) had markedly improved growth of the groundnut crop in terms of impact on morphological and photosynthetic components. A faster growth rate in terms of dry matter production evidenced as higher CGR from initial (germination) till harvest under the influence of balanced fertilization (RDF) + bio-inoculations (PSB+AMF) as soil application might have played a significant role for providing all essential nutrients to plant. Hence reducing competition for nutrients, resulting in healthy and robust plants and more photosynthates production. The increasing trend of physiological traits have been due to the fact that soil applied nutrients possibly have been used for maximum for development of ancillary growth characters which leads to higher growth rate (CGR and RGR). This suggests greater availability of metabolites for development of reproductive structures (sink) also, which ultimately leads to realization of higher productivity of individual plant and resultant higher yields of groundnut. The present investigation results are in close conformity with those reported by Patil *et al*. (2014) and Vala *et al*. (2017).

Tillage and fertilizer interactions: Data showed interaction effect of tillage practices and fertilizer management on pod yield of groundnut (Table 2). Result indicated that under different tillage practices with no fertilizer (F_0) application, recorded lower pod yield during both the years and on pooled basis. Data further revealed that pod yield improved by applying different fertilizer over

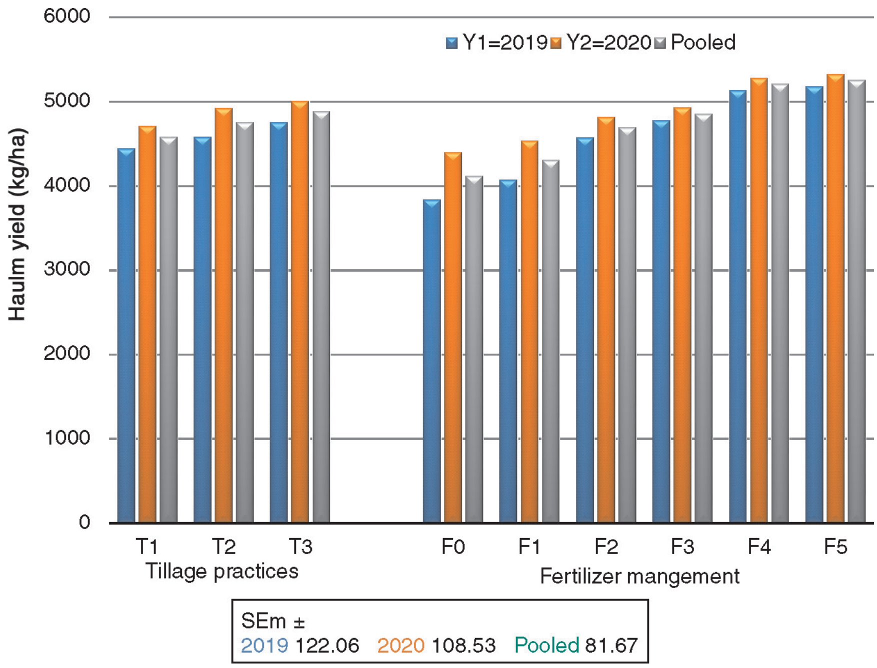

Fig 2 Effect of tillage and fertilizer management practices on haulm yield (kg/ha) of groundnut.

Table 2 Interaction effect of tillage and fertilizer management on pod yield and haulm yield of groundnut

Treatment	Pod Yield (Pooled) kg/ha			Haulm yield (Pooled) kg/ha		
	T_1	T_2	T_3	T_1	T_2	T_3
F_0	1985	2330	2485	3903	4210	4227
F_1	2287	2538	2619	4081	4458	4361
F_2	2666	2858	2856	4546	4714	4807
F_3	2783	2981	3010	4621	4838	5088
F_4	3016	3179	3418	5114	5113	5380
F_5	3077	3229	3499	5173	5168	5403
F at same level of T	LSD (P=0.05) 134.88			LSD (P=0.05) 221.59		
T at same level of F	LSD (P=0.05) 172.73			LSD (P=0.05) 274.37		

where, F- Fertilizer management practices, T- Tillage practices.

control under all the three tillage practices. The highest pod yield of 3602, 3398 and 3499 kg/ha was observed under $T_3 \times F_5$ i.e. conventional tillage and RDF + PSB @2.5 kg/ha + AMF @4 kg/ha was at par with $T_3 \times F_4$ treatment combination during both the years and on pooled basis. The treatment combination $T_3 \times F_5$ gave significantly higher pod yield over rest all treatments but was statistically at par with $T_2 \times F_4$ and $T_2 \times F_5$ during the year 2020. The higher pod yield with combined tillage (conventional) and fertilization (F_4 or F_5) may be due to pulverized seed bed and balance availability of nutrients. These findings collaborate with Memon *et al.* (2013) which reported that tillage with NPK and FYM increased seedling emergence percentage and higher filled grain in maize crop.

Result further indicate that different tillage practices with no fertilizer record lowest haulm yield during both the years and on pooled basis. The haulm yield improved by applying varying fertilizer treatments under all tillage practices in comparison to control. The highest haulm yield was observed under treatment combination $T_3 \times F_5$ i.e. conventional tillage and application of RDF + PSB @2.5 kg/ha + AMF @4 kg/ha was at par with $T_3 \times F_4$ treatment combination during both the years and on pooled basis. Significant and positive interaction between applied N and water supply was observed on wheat yield (Bhale *et al*. 2009). Memon *et al.* (2013) reported that tillage with NPK and FYM increased taller plants with more number of leaves and dry matter yield of maize crop.

The study showed that performance of groundnut crop was found similar under deep tillage and conventional tillage practices in terms of yields (pod and haulm). The ancillary crop parameters increased with the combined application of chemical fertilizer with bio-inoculants. In two years of study, the maximum pod yield (3566.75, 3602.25 kg/ha) and haulm (5328.25, 5394.75 kg/ha) were observed with the application of RDF + PSB @2.5 kg/ha + AMF @2 or 4 kg/ha. Best combination of fertilizer (F5) improved the water and nutrient use efficiency by 16.7% and 90.2% higher as compared to RDF alone. In dry and hot regions of Rajasthan, deep tillage along with combined application RDF with all bio-inoculants may be recommended for getting higher yields and resource (water and nutrient) use efficiency instead on conventional tillage and fertilizer management practices.

REFERENCES

Aduloju M O, Mahmood J and Abayomi Y A. 2009. Evaluation of soybean (*Glycine max* L.) genotypes for adaptability to Southern Guinnea Savanna environment with and without P fertilizer application in north Central Nigeria. *African Journal of Agricultural Research* **4**: 556–63.

Bhale V M and Wanjari S S. 2009.Conservation agriculture: A new paradigms to increase resource use efficiency. *Indian Journal of Agronomy* **54**(2): 167–77.

Borkar V H and Dharanguttikar V M. 2014. Evaluation of groundnut (*Arachis hypogaea* L.) Genotypes for physiological Traits. *International Journal of Scientific and Research* **4**(1): 2250–3153.

Chaudhary J H, Sutaliya R and Desai L J. 2015. Growth, yield, yield attributes and economics of summer groundnut as influenced by integrated nutrient management. *Journal of Applied and Natural Science* **7**(1): 369–72.

Dutta J K, Ghosh A, Banerjee A, Mondal N K. 2012. Biochemical response of selected plant species under air pollution stress. *Ecology, Environment and Conservation* **18**: 957–62.

Ibragimov N, Evett S, Esenbekov Y, Khasanova F, Karabaev I, Mirzaev L and Lamers J. 2011. Permanent Beds vs. Conventional Tillage in Irrigated Arid Central Asia. *Agronomy Journal* **103**(4): 1002–11.

Jabro J D, Stevens W B, Iversen W M and Evans R G. 2011. Bulk density, water content, and hydraulic properties of a sandy loam soil following conventional or strip tillage. *Applied Engineering in Agriculture* **27**: 765–68.

Kumar N, Kumar A, Shukla A, Ram A, Bahadur R and Chaturvedi O P. 2018. Effect of application of bio-Inoculants on growth and yield of *Arachis hypogaea* L. and *Sesamum indicum* L. *International Journal of Current Microbiology and Applied Sciences* **7**(1): 2869–75.

Yadav M, Yadav S S, Kumar S, Yadav H K and Tripura P. 2017. Effect of Phosphorus and Bio-fertilizers on Yield, Nutrient Content and Uptake of Urdbean [*Vigna mungo* (l.) Hepper]. *International Journal of Current Microbiology and Applied Sciences* **6**(5): 2144–51.

Memon S Q, Mirjat M S, Mughal A Q and Amjad N. 2013. Effect on conventional and non-conventional tillage practices on maize production. *Pakistan Journal of Agricultural Engineering and Veterinary Sciences* **29**(2): 155–63.

Ortas I. 2012. The effect of mycorrhizal fungal inoculation on plant yield, nutrient uptake and inoculation effectiveness under long-term field conditions. *Field Crops Research* **125**: 35–48.

Panse V G and Sukhatme P V. 1985. *Statistical methods for agricultural workers*. Indian Council of Agricultural Research, New Delhi.

Parihar C M, Rana K S, Jat M L, Jat S L, Parihar M D, Kantwa S R, Singh D K and Sharma S. 2012. Carbon footprint and economic sustainability of pearl millet–mustard system under different tillage and nutrient management practices in moisturestress condition. *African journal of microbiology research* **6**(23): 5052–61.

Patil S R, Kadam S R, Kalegore N K and Dadgale P R. 2014. Effect of inorganic and bio-fertilizers on growth and yield of summer groundnut. *Advance Research Journal of Crop Improvement* **5**(1): 23–25.

Rai S K, Charak D and Bharat R. 2016. Scenario of oilseed crop across the globe. *Plant Archives* **16**(1): 125–32.

Reddy, R S, Triveni, S. and Chari, K.D. 2016. Biofertilizers for sustainable production in oil seed crops. *Scholars Journal of Agriculture and Veterinary Sciences* **3**(6): 435-441.

Sharma G R, Shankar G R M, Akbari K N, Reddy K S and Sutaria G S. 2014. Efficient tillage practices for maximum infiltration, rain water use efficiency and profitability from ground nut under semi arid vertisols in western India. *Journal of Irrigation and Drainage Engineering* **140**(3): 04013019.

Sinha B L. 2015. Effect of Tillage Practices and Nutrient Management on Yield of Pearl millet and Soil Health in Semi Arid Tropics. *International Journal of IT, Engineering and Applied Sciences Research* **4**(2): 33–39.

Usman Y M, Hussaini M, Baba-Musami B and Sheriff B. 2014. Effect of Different Tillage Methods on the Growth and Yield of Pearl Millet under Rainfed Conditions. *The International Journal of Science & Technoledge* **2**(11).

Vala F G, Vaghasia P M, Zala K P and Buha D B. 2017. Effect of Integrated Nutrient Management on Productivity of Summer Groundnut (*Arachis hypogaea* L.). *International Journal of Current Microbiology and Applied Sciences* **6**(10): 1951–57.

Zamir M S I, Javed H M R, Ahmed W, Ahmed A U H, Sarwar N, Shehzad M, Sarwar M A and Iqbal S. 2012. Effect of Tillage and Organic Mulches on Growth, Yield and Quality of Autum Planted Maize (*Zea mays* L.) and Physical Properties. *Cercetari Agronomice in Moldova* XLVI **2**(154): 17–26.