www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(7): 222-230
© 2020 TPI
www.thepharmajournal.com
Received: 12-05-2020
Accepted: 16-06-2020

T Ramesh
Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirapalli, Tamil Nadu, India

S Rathika
Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirapalli, Tamil Nadu, India

G Nagarajan
Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirapalli, Tamil Nadu, India

P Shanmugapriya
Department of Agronomy, Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India

Corresponding Author:
T Ramesh
Department of Agronomy, Anbil Dharmalingam Agricultural College and Research Institute, Tamil Nadu Agricultural University, Tiruchirapalli, Tamil Nadu, India

Land configuration and nitrogen management for enhancing the crop productivity: A review

T Ramesh, S Rathika, G Nagarajan and P Shanmugapriya

Abstract
Land configuration techniques such as ridges and furrows and broad bed and furrow can play a vital role to overcome soil related problems by providing easy and uniform germination as well as good growth and development of plants. The recommended land configuration for finger millet is flat bed which produces lesser yield mainly because of poor soil hydro regimes. It is highly essential to investigate the benefits of improved land configuration techniques like ridges and furrows and broad bed and furrow on the productivity of various crops. Land configuration plays a major role in minimizing soil erosion and improving water and nutrient use efficiency of field crops. Most of the crops normally grow on poor, marginal soils with imbalanced nutrient application. Among various nutrients, nitrogen is an inevitable nutrient for any crop. Nitrogen (N) management is also one of the most important factor required for improving crop productivity and profitability under semi-arid climates.

Keywords: Land configuration, nitrogen management, growth, yield, nutrient uptake, economics

Introduction
Our agricultural systems are more diverse in nature due to the vagaries in climatic factors such as temperature, rainfall and CO_2 and poor physical soil condition plays a major role in determining the productivity of crops. Beside these phenomenon's, most of the soils in the semi-arid tropics are deficient in major and micronutrients, mainly due to continuous cropping, low use of mineral fertilizer, poor recycling of crop residues, and low rates of organic matter application which can limit yield potential. Increasing the use of inorganic fertilizers and other agricultural chemical inputs is not a viable strategy for improving the yield and productivity of crops. Sustainable agricultural practices are to be followed for effective utilization of inputs and in turn it conserves the agro-ecosystems by maintaining its stability. Land configuration and appropriate nutrient management plays a major role for improving the input use efficiency and crop production.

Land configuration helps for maximizing rainfall infiltration, minimizing erosion, total runoff, facilitates drainage and ultimately improves water use efficiency. Modification of land through broad bed and furrow and ridges and furrows would reduce the soil related problems and improve the crop growth and yield. The raised bed zone of broad bed and furrow system is better aerated with lower penetration resistance and favourable for deeper seed placement and better crop emergence (Jayapaul *et al*., 1996) [31]. Parihar *et al.* (2009) [52] reported that ridges and furrows sowing method improved the grain as well as stover yield of pearl millet and succeeding mustard over the flat bed method of sowing. Under rainfed conditions, ridges may help with conservation and availability of moisture for a relatively longer time. With high rainfall, the furrows between the ridges may help drained out of excess water from the crop root zone, improved soil temperature, aeration and nutrient availability and also enhanced the depth of crop root zone (Parihar *et al.*, 2012) [53].

Among the other factors, nutrient management is considered as the most crucial one for improving the growth and productivity of crops. Low productivity of crop as well as poor quality was mainly due to adoption of improper nutrient management techniques. In concerned with this, Indian soils are mostly deficient in terms of nitrogen. Nitrogen is the most yield-restraining nutrient in crop production at global level (Guo *et al.*, 2016) [21]. It is well known that, most of the crops require nitrogen for its healthy vegetative growth during the initial phase of the crop. nitrogen management is one of the most important factors required for improving crop productivity and profitability under semiarid climates (Amanullah, 2016) [2].

Hence, it is important to review the effect of land configuration techniques *viz.*, ridges and furrows and broad bed and furrow and nitrogen management on growth and productivity of different crops.

Different land configurations

Land configuration techniques are used to maintain required soil moisture in the root zone of the crop. Land configuration is the technique by which the rain water has to be trapped on the soil surface when rainfall exceeds infiltration rate. The purpose of this technique is to improve the water storage in the soil profile during the crop growing season (Ramesh and Rathika, 2009) [63].

In broad bed and furrow technique, field is divided into narrow strips of broad beds separated by furrows. The seed is sown on the broad bed surface. Whenever there is a rain or irrigated, the water get collected in the furrows and the lateral water movement fulfills the crop water requirement. Whenever there is excess rain, the water flows through the furrows and the stagnation of water avoided. It is highly essential to investigate the benefits of improved land configuration techniques like ridges and furrows and broad bed furrows on the productivity of different crops.

Land configuration techniques such as ridges and furrows and broad bed furrows can play a vital role to overcome soil related problems in sodic soil by providing easy and uniform germination as well as good growth and development of plants. Ridges and furrows is a method of land preparation whereby the top soil is scraped and concentrated in a defined region to deliberately raise the seedbed above the natural terrain. In other words, it could be explained as formation of bunds parallel to each other in the field at appropriate intervals for sowing/planting wide spaced crops like cotton, sugarcane etc. Bunds are referred as ridges and the depression in between bunds are referred as furrows (Ramesh and Rathika, 2009) [63]. Sharma *et al.* (2018) [75] reported that the crop growth characteristics i.e. plant height, dry matter accumulation and grain yield were significantly affected by different land configuration methods.

Effect of land configurations on soil moisture availability

Different land configurations *viz.*, broad bed and furrow, ridges and furrow, contour cultivation and open furrow in between crop rows plays a major role in reducing the surface runoff and increasing the soil moisture content.

In *Vertisols*, broad bed and furrow with 120-150 cm wide was quite essential for performing cultural operations and minimizing runoff of excess water (ICRISAT, 1978) [25]. Alleviation of problems of water logging, planting on modified land configurations such as broad bed and furrow was found to be advantageous (Desai *et al.*, 2000) [12]. Broad bed and furrow recorded 11.4 per cent higher soil moisture over traditional flat bed (Selvaraju and Balasubramanian, 2001) [73]. Similarly, land configuration like broad bed and furrow increased infiltration of rain water and it helped to improve moisture storage in soil profile (Vaghasia *et al.*, 2007) [84]. Broad bed and furrow conserved higher soil moisture (33.5 per cent) followed by ridges and furrows (34.3 per cent) (Devaranavadgi and Bosu, 2014) [14]. Chouhan *et al.* (2015) [9] found that in summer pearl millet normal drilling recorded higher moisture availability for crop owing to better moisture conservation, due to more vegetative growth resulting from efficient utilization of nutrients, water, radiation and increased metabolic activities. Gnanasoundari and Balusamy (2015) [20] stated that broad bed furrow system recorded the maximum soil moisture percent both at 20 cm and 40 cm depth on 30, 60, 90 and 120 DAS. This might be due to broad bed furrow system helps in the safe disposal of excess water through furrows when there is high intensity rainfall with minimal soil erosion, at the same time it serves as land surface treatment for in-situ moisture conservation. Hanamant and Angadi (2019) [22] found that in cowpea broad bed furrow system resulted in higher soil moisture content (32.09% at 40 DAS).

Ridges and furrows stored appreciable quantity of moisture but were not as effective as the broad bed and furrow and compartmental bunding land configurations in black soil areas (Selvaraju and Balasubramanian, 2001) [73]. Menon *et al.* (2007) [42] found that soil moisture content was higher in ridge sowing method as compared to broadcasting methods of sowing. Reddy *et al.* (2009) [69] opined that ridges and furrow made using tractor drawn furrower at 0.9m spacing consistently recorded higher amount of soil moisture from sowing to harvest at top 0.4m soil depth. This might be due to the furrows might increased the time to run off initiation so there is more opportunity time for infiltration and better soil moisture conservation. Li *et al.* (2010) [41] stated that better conditions for plant growth are provided in-furrow planting due to higher soil moisture, higher salt leaching and reduction in evaporation from the soil surface. Thakur *et al.* (2011) [81] observed that ridge and furrow system recorded 16.7 per cent and 28.6 per cent higher maize grain yield than flat system in the 2007 and 2008 respectively, due to proper drainage of excess rain water and increased availability of moisture to the plants. Ambika *et al.* (2017) [3] observed that ridges and furrows recorded significantly higher soil moisture at the depths of 0-15, 15-30, 30-45 and 45-60 cm of soil depth (28.44, 28.46, 29.27 and 29.61%, respectively) at the time of sowing in comparison to conventional flat bed (25.42, 25.92, 26.42 and 26.84, respectively). Ridges and furrows retained higher soil moisture content at the root zone depth (0-10 and 10-20 cm) at all the stages of crop growth over broad bed furrows and flat bed (Nagarajan *et al.*, 2018) [48]. Kumar *et al.* (2018) [38] reported that higher plant dry matter accumulation, number of tillers per plant, and ear length were recorded higher under furrow sowing method. This might be due to maintenance of proper air moisture regimes under furrow sowing which might have improved the drainage resulting in good supply of required moisture, available nutrients, soil aeration, soil environment and better growth and development.

Effect of land configuration on growth attributes

Broad bed and furrow system in groundnut showed significantly higher leaf area index due to its favorable effects on soil properties and optimum soil moisture regimes even after heavy and low rainfall (Ashok and Rana, 2004) [4]. Rathore *et al.* (2010) [67] stated that significantly higher plant height (37.65 cm), number of branches (8.28 plant^{-1}), number of leaves (20.03 plant^{-1}), dry weight of plant (8.18 g) and number of root nodules (35.50 plant^{-1}) under broad bed and furrow in black gram. In black cotton soil, Elamathi (2014) [18] reported that the broad bed and furrow recorded taller plants than flat bed in sorghum. Similarly, Paslawar and Deotalu (2015) [54] stated that broad bed and furrow exhibited higher plant height, sympodial branches and dry matter production over the other treatments in cotton. Growth parameters *viz.*, plant height (68.9 cm), branches per plant, dry matter production (14.7 g plant^{-1}) were significantly higher under broad bed and furrow in urd bean (Tomar *et al.*, 2016) [82]. Similarly, the highest plant height (43.1, 45.4 cm), dry matter accumulation per plant (25.2, 36.3 g) and number of nodules per plant (53.6, 47.6) at 60 DAS and at harvest were recorded under raised bed method of sowing than flat bed method of sowing in cowpea (Joshi *et al.*, 2018) [32].

The positive effects of ridges and furrows on enhancing the plant height of sorghum, cowpea, bengal gram and sunflower have been reported by Somasundaram *et al.* (2000) [78]. Ridges and furrows planting produced significantly taller plants, more branches/plant and leaf area index than flat bed planting on pigeon pea at IARI, New Delhi (Jat and Ahlawat, 2001) [29]. Ridges and furrows registered higher growth attributes *viz.*, plant height and dry matter production in soybean (Lakpale and Tripathi, 2012) [39]. Dhakad *et al.* (2014) [15] stated that ridges and furrows registered significantly higher plant population (44.8 and 46.2 m^{-2} at 2009 and 2010, respectively), plant height (67.4 and 69.4 cm at 2009 and 2010, respectively) than flat bed in soy bean. In sweet corn, significantly higher plant height (170.0 cm) and number of leaves (14.0 per plant) were reported under ridges and furrows than flat bed (Nagdeote *et al.*, 2016) [49]. Singh *et al.* (2017) [77] stated that furrow sowing was significantly superior over other land configuration methods in terms of growth parameter (Plant height, functional leaves plant^{-1}, LAI, total branches plant^{-1}, dry matter accumulation) in mustard cultivation. Nagarajan *et al.* (2018) [48] reported that ridges and furrows registered significantly taller plants (98.2 cm), more number of tillers (210 m^{-2}), dry matter production (9932 kg ha-^{1}) at harvest stage and higher leaf area index (4.75) and SPAD reading (39.8) at flowering stages in finger millet. Kumar *et al.* (2018) [38] reported that in pearl millet maximum plant height (197.43 cm) was recorded in ridge sowing, while the lowest plant height (176.73 cm) was recorded in broadcast method. This might be due to ridge bed patterns provided favorable environment, where water was used more efficiently, and resulted in better vegetative growth. Sharma *et al.* (2018) [75] found that in pearl millet maximum plant wet biomass of 155.98 and 253.27 g plant^{-1}, higher number of tillers was recorded 3.47 and 4.04 plant^{-1} at booting and physiological maturity stages, respectively, was obtained with ridge method of planting.

Effect of land configurations on root growth

The highest yield of sorghum and pearl millet under broad bed and furrow resulted increased root density, which facilitated extraction of more available nutrients (Nicou *et al.* 1993) [50]. Broad bed and furrow induced good root development, good nodulation, better crop growth, better pod filling and early maturity in groundnut, besides considerable saving of time and cost of cultivation compared to flat bed (Ingole *et al.*, 1998) [26].

Patil and Sheelavantar (2004) [60] opined that compartmental bunding and ridges and furrows recorded appreciable increase in root depth (48.1 and 51.9 cm, respectively) over flat bed (39.4 cm) in sorghum. Ridges and furrows recorded significantly higher root length, root volume, root dry weight of 19.3 cm, 1.68 cc and 0.63 g respectively, over flat bed in cowpea (Ramesh and Devasenapathy, 2006) [62]. Root parameters *viz.*, root length, root volume and root dry weight were (27.2, 16.8 and 40.6 per cent, respectively) higher with ridges and furrows followed by raised bed (19.3, 10.0 and 24.7 per cent, respectively) over zero tillage in maize (Choudhary *et al.*, 2013) [8]. Ridges and furrows observed significantly higher root length of 24.77 and 26.22 cm at 2009 and 2010, respectively than flat bed in soybean (Dhakad *et al.*, 2014) [15]. Nagarajan *et al.* (2018) [48] found that ridges and furrows increased root growth activity due to higher soil moisture content and nitrogen availability, which ultimately increased the N uptake by the crops.

Effect of land configurations on yield attributes

The yield parameters *viz.*, number of clusters (11.88 plant^{-1}), number of pods (36.29 plant^{-1}), pod length (3.89 cm) and number of seeds (6.20 pod^{-1}) under broad bed and furrow in black gram (Rathore *et al.*, 2010) [67]. Similarly, the yield parameters *viz.*, 100 seed weight, number of pods per plant^{-1} found under broad bed and furrow in soy bean (Jadhav *et al.*, 2012). Yield attributing characters of maize crop *viz.*, number of grain row per cob (31.23), number of grains per cob (410.15) and grain yield (6097 kg ha^{-1}) were higher under broad bed and furrow system (NICRA, 2014). Gnanasoundari and Balusamy (2015) [20] reported that cotton crop grown in broad bed and furrow system registered higher yield parameters *viz.*, no. of sympodial branches/plant (21.7), number of bolls per plant (43.2) and boll weight (3.96 g) and significantly higher seed cotton yield of 2658 kg/ha. In urd bean, yield parameters *viz.*, pods per plant (20.1), seeds per pod (5.1), test weight (42.6 g) were higher under broad bed and furrow (Tomar *et al.*, 2016) [82]. Similarly, number of pods per plant was significantly higher under raised bed method of sowing as compared to flat bed method of sowing in cowpea (Joshi *et al.*, 2018) [32]. Yadav *et al.* (2019) [87] found that in maize maximum number of cobs (1.40), cob length (21.9 cm), cob width (13.3 cm), grain rows per cob (15.0), number of grains per row (40.4) and 100 seed weight (27.0 g) were recorded under broad bed and furrow sowing method.

Lal *et al.* (2007) [40] registered higher yield attributes *viz.*, effective tillers (9.1 m^{-2}), earhead length (18.1 cm) and test weight (7.96 g) under ridges and furrows than farmers practice of flat bed in pearl millet. In cluster bean, ridges and furrows registered the highest pod length (8.35 cm), pod weight (7.50 g) and pod girth (78.0 cm) than flat bed (Allolli *et al.*, 2008) [1]. Ridges and furrows registered significantly higher cob length (21.02 cm) and girth (16.66 cm) and number of kernels (487.16) in sweet corn than other land configurations (Nagdeote *et al.*, 2016) [49]. Similarly, Saha *et al.* (2017) [71] reported that significantly higher number of pods (14.56 plant^{-1}), number of seeds (7.26 pod^{-1}) and number of cluster (4.66 plant^{-1}) under ridges and furrows than flat bed in guar gum. Singh *et al.* (2017) [77] found that furrow sowing resulted in higher yield attributes (no. of siliqua plant^{-1}, siliqua length, seeds siliqua^{-1} and test weight) in mustard cultivation. Sharma *et al.* (2018) [75] opined that in the ridge method, ear diameter of pearl millet was respectively 8.5, 16.7 and 23.3 per cent higher than bed, seed drill and broadcast methods. The higher ear diameter was largely due to better growth of plant in terms of biomass production under ridge and furrow sowing which might have adequately supplied more photosynthates for development of sink. Nagarajan *et al.* (2018) [48] found that ridges and furrows produced significantly more number of productive tillers (196 m^{-2}), length of finger (6.1 cm), number of grains per earhead (1789) and earhead weight (6.4 g) as compared to broad bed furrows and flat bed.

Effect of land configurations on yield

Broad bed and furrow practice increased the grain yield of sorghum and pearl millet by 34 and 33 per cent respectively, with optimum water storage and safe disposal of excess rain water over the flat bed in high rainfall year (Selvaraju *et al.*, 1999) [74]. Grain yield of finger millet was 13.45 per cent higher in broad bed and furrow system over the flat bed method of sowing (Muthamilselvan *et al.*, 2006) [46]. Patel *et al.* (2009) [57] reported that higher seed cotton yield of 2390 kg ha^{-1} was obtained under raised bed than other configurations in cotton. Rathore *et al.* (2010) [67] stated that significantly higher seed yield (1254 kg ha^{-1}) and straw yield (8997 kg ha^{-1}) were noticed under broad bed and furrow than flat bed in black gram. The stover yield of maize (101.26 q ha^{-1}) and haulm yield of chickpea (10.00 q ha^{-1}) were also significantly higher with broad bed and furrow (Chavan, 2011) [7]. Patil *et al*. (2011) reported that significantly higher seed yield (11.42 q ha^{-1}) and straw yield (16.77 q ha^{-1}) under broad bed and furrow in linseed. Broad bed and furrow increased the maize yield by 23.38 per cent (5431 kg ha^{-1}) over flat bed due to enhanced soil moisture availability in deep clay soils. Broad bed and furrow and ridges and furrows recorded higher grain yield of sorghum than flat bed (Elamathi, 2014) [18]. Significantly higher pod (932 kg ha^{-1}) and haulm (3234 kg ha^{-1}) yields were obtained under the broad bed (90 cm width) and furrow (45 cm) as compared to flat bed technique in groundnut (Vekariya *et al.*, 2015) [85]. Hanamant and Angadi (2019) [22] found that in cowpea higher grain yield (13.4 q ha^{-1}), haulm yield (25.6 q ha^{-1}) and harvest index (34.4%) were recorded with broad bed and furrow method of planting.

Singh *et al.* (1996) [77] reported that 17 per cent increase in mean grain yield of pearl millet under ridges and furrows sowing than flat bed sowing. Tumbare and Bhoite (2003) [83] revealed that ridges and furrows method of sowing recorded higher grain yield of pearl millet and chickpea which was 38.15 and 23.78 per cent higher than flat bed method of sowing, respectively. Ridges and furrows were found beneficial in conserving higher soil moisture and resulted in higher grain yield (15.78 q ha^{-1}) of *rabi* sorghum compared to flat bed method of sowing (11.74 q ha^{-1}) (Kiran and Lingaraju, 2005). Ridges and furrows produced a higher grain yield (662.8 kg ha^{-1}) compared to flat bed (572.2 kg ha^{-1}) in cowpea (Ramesh and Devasenapathy, 2006) [62]. Grain yield of 1130 kg ha^{-1} and fodder yield of 1589 kg ha^{-1} in pearl millet under ridges and furrows than farmers practice in Jodhpur (flat bed) (Lal *et al.*, 2007) [40]. Parihar *et al.* (2009) [52] reported that ridges and furrows method of sowing improved grain as well as stover yield of pearl millet and succeeding mustard over the flat bed method of sowing. Ridges and furrows sowing of pearl millet showed that increase in grain and stover yield under ridges and furrows were 20.0 and 17.7 per cent over flat bed sowing, respectively (Deshmukh *et al.*, 2013) [13]. Ridges and furrows recorded significantly higher seed yield (1456 and 1568 kg ha^{-1} at 2009 and 2010, respectively) than flat bed (Dhakad *et al.*, 2014) [15]. Ambika *et al.* (2017) [3] stated that seed cotton yield was higher with ridges and furrows (2403 kg ha^{-1}) over broad bed and furrow (2222 kg ha^{-1}) and flat bed (conventional method) (1743 kg ha^{-1}). The higher length of panicle (23.60 cm), girth of panicle (9.34 cm), no. of grains panicle^{-1} (1786.13), test weight (11.41 g), grain yield (17.73 q ha^{-1}) and straw yield (51.10 q ha^{-1}) were noticed under furrow sowing method in pearl millet (Kumar *et al.*, 2018) [38]. Sharma *et al.* (2018) [75] found that ridge planting had significantly maximum grain yield (18.43 q ha^{-1}), while, broadcast planting had the lowest grain yield (16.52 q ha^{-1}) in pearl millet. Nagarajan *et al.* (2018) [48] reported that higher grain and straw yields (3428 and 6589 kg ha^{-1}) were registered under ridges and furrows over broad bed furrows and flat bed in finger millet crop under sodic soil condition. This was due to the fact ridges and furrows land configuration reduced the soil compaction, salt accumulation at the root zone and increased the root activity and microbial population in the rhizosphere of sodic soil ecosystem.

Effect of land configurations on nutrient uptake

Broad bed and furrow and ridges and furrows systems significantly increased N, P, K and S uptake than flat bed system in sorghum (Patil and Sheelavantar, 2000) [59]. Similarly, Muralidaran and Solaimalai (2005) [45] reported that broad bed and furrow system of sowing registered significantly higher nitrogen uptake of 53.8, 96.1 and 103.0 kg ha^{-1} at squaring, flowering and maturity stage, respectively than flat bed system of sowing in cotton. Broad bed and furrow system of planting recorded higher N and P uptake in pigeon pea over flat bed planting (Kantwa *et al.*, 2006) [36]. Chavan (2011) [7] also stated that at harvest total nitrogen uptake in maize was higher with broad bed and furrow (312 kg ha^{-1}) and compartmental bunding (265 kg ha^{-1}) over farmer's practice (207 kg ha^{-1}). The uptake of nitrogen by green gram was significantly higher under raised bed method of sowing than flat bed method (Jat *et al.*, 2012) [30]. Whereas, Patel *et al.* (2013) [56] recorded that the uptake of N was numerically higher with broad bed and furrow system, whereas P and K were higher under ridges and furrows technique.

Ridges and furrows sowing proved superior to flat sowing method and increased mean protein production and nitrogen uptake in pearl millet by 24.4 and 23.1 per cent, respectively (Singh *et al.*, 1996) [77]. In cowpea, ridges and furrows recorded significantly higher N uptake (36.7 kg ha^{-1}) than flat bed (30.1 kg ha^{-1}) (Ramesh and Devasenapathy, 2007). The N uptake (131.31 kg ha^{-1}) and P uptake (29.35 kg ha^{-1}) were recorded higher under normal drilling in summer pearl millet crop (Chouhan *et al.*, 2015) [9]. Ridges and furrows noticed higher nitrogen uptake of 152.64 and 149.21 kg ha^{-1} at 2011 and 2012, respectively in sweet corn than flat bed (Nagdeote *et al.*, 2016) [49]. This might be attributed to better root growth due to better aeration and good drainage might have also increased microbial activity with optimum moisture and nutrient availability for its growth. Sharma *et al.* (2018) [75] observed that in pearl millet ridge method recorded significantly higher nitrogen content in grains and stover than other methods. The increases in percentage of N from ridge planting method over broadcast, seed drill and bed were respectively 6.91, 5.63 and 4.2% in grain.

Effect of land configurations on economics

Ridges and furrows planting recorded higher net return (Rs 15426 ha^{-1}) and return per rupee invested (Rs 1.54) over flat planting (Rs 13751 ha^{-1} and 1.43) on pigeon pea at IARI, New Delhi (Jat, 1999) [28]. The ridges and furrows system may help to increase the income to the farmer besides preventing land degradation due to runoff erosion (Patil and Sheelavantar, 2004) [60]. Similarly, ridges and furrows sowing with recommended fertilizer in 3 equal splits gave significantly higher net income of Rs. 19829 ha^{-1} and BC ratio of 2.55 in pearl millet. Ridge sowing of maize recorded higher net returns of Rs. 18042 ha^{-1} and BC ratio of 2.02 compared to flat sowing (CRIDA, 2010). The ridges and furrows system gave an additional income of Rs. 6262 ha^{-1} compared to the flat system in *Kharif* sorghum (Thakur *et al.*, 2011) [81]. Deshmukh *et al.* (2013) [13] reported that ridges and furrows along with early sowing during summer season was beneficial to obtain higher net returns from pearl millet and ridge and furrow sowing gave a net returns of Rs.14081 ha^{-1} and BC ratio of 1.88 while, in flat bed treatment those were Rs.10181 ha^{-1} and 1.67, respectively. The highest net return (Rs.77190 ha^{-1}) was obtained in compartmental bunding followed by ridges and furrows (Kalhapure and Shete, 2013) [35]. Dhakad *et al.* (2014) [15] reported that the highest net return (Rs. 31676 ha^{-1}) and BC ratio (2.71) under ridges and furrows in soybean. The lowest net return (Rs. 18790 ha^{-1}) and BC ratio (2.04) was recorded under flat bed condition. Ridges and furrows registered higher gross returns of Rs. 181839 ha^{-1}, net returns of Rs. 114759 ha^{-1} and BC ratio of 2.79 in sweet corn than flat bed (Nagdeote *et al.*, 2016) [49]. The land configuration practices, furrow sowing recorded maximum gross income (Rs. 78923.50 ha^{-1}), net return (Rs. 58968.9 ha^{-1}) and BC ratio (2.96 ha^{-1}) followed by ridge bed sowing and BBF sowing recorded higher gross income (Rs. 77292.50 ha^{-1}, Rs. 76630.50 ha^{-1}), net income (Rs. 57337.9 ha^{-1}, Rs. 56675.9 ha^{-1}) and BC ratio (2.87, 2.84) respectively, minimum gross return (Rs. 75301.50 ha^{-1}), net return (Rs. 55546.9 ha^{-1}) and BC ratio (2.81) were recorded with flatbed broadcasting (Kumar *et al.*, 2018) [38]. Sharma *et al.* (2018) [75] opined that higher BC ratio 2.20:1 was recorded for ridge planting in pearl millet.

Nitrogen management

In most of the arid and semi arid regions of the world, the major constraints in the productivity of crops are due to poor soil fertility and erratic rains. Soil fertility management plays a vital role in increasing the production and productivity of crops. Nitrogen is one of the most essential and yield limiting nutrients for crop production in different agro-ecosystems. Worldwide over 80 million metric tons of nitrogen fertilizers per year has been applied (Epstein and Bloom, 2005) [29]. It is the nutrient element applied in the largest quantity for most annual crops (Huber and Thompson, 2007) [24]. Nitrogen plays a major role in the early establishment of leaf area and promotes leaf and stem growth rapidly which consequently increase the yield and its quality.

Effect of nitrogen levels on growth parameters

Increasing levels of nitrogen in finger millet significantly increased the plant height upto 60 kg N ha^{-1} in all the three years and though there was further increase upto 90 kg N ha^{-1}, the difference was significant only during 1969 (Mishra *et al.*, 1973) [43]. Similarly, Rao *et al.* (1984) [65] observed that 120 kg ha^{-1} of nitrogen application in irrigated finger millet significantly influenced the dry matter production at all the stages of crop growth. Application of nitrogen at 60 kg ha^{-1} for finger millet showed significant increase in plant height, number of productive tillers m^{-2} (234) on sandy loam soils at Regional Research Station, Tirupathi (Babu *et al.*, 2003) [5]. Application of 60 kg ha^{-1} nitrogen recorded significantly higher plant height (110.3 cm) which was on par with 40 kg ha^{-1} nitrogen application in finger millet (Yadav *et al.*, 2010) [87]. Mudalagiriyappa *et al.* (2015) [44] reported that application of 150% customized fertilizer dose (100.41 g/hill) recorded significantly higher total dry matter accumulation in finger millet. Sandhya Rani *et al.* (2017) [72] reported that growth parameters like plant height (120.3 cm), leaf length (29.1 cm) were higher under 150 per cent recommended dose of fertilizers than recommended dose of fertilizers in finger millet. Ramesh and Rathika (2017) [64] reported that growth parameters of rice at flowering stage revealed that the green manure + 100% N produced significantly taller plants (128.2 cm), tillers per hill (23), leaves per plant (61), LAI (5.4), shoot dry weight (49 g/plant), root length (26 cm), root dry weight (21.3 g/plant) over green manure alone and control. However, this was comparable with green manure + 75% N and 100% N without green manure. Yadav *et al.* (2019) [86] reported that application of nutrients through basal + N through LCC recorded significantly the highest plant height (218.3 cm) over all the remaining methods of nutrient application.

Effect of nitrogen levels on yield attributes

Application of 80 kg ha^{-1} of nitrogen increased the productive tillers $hill^{-1}$ in finger millet (Reddy *et al.*, 1986) [68]. Maximum number of productive tillers m^{-2} and number of finger $earhead^{-1}$ were obtained with 90 kg ha^{-1} and it was on par with 60 kg ha^{-1} and was significantly superior over lower levels of nitrogen in finger millet on sandy soils at Agricultural College Farm, Bapatla (Mutyalu *et al.*, 1992) [47]. Application of 50 kg N ha^{-1} increased number of productive tillers $plant^{-1}$ and number of fingers ear $head^{-1}$ of finger millet at Bijapur (Kalaghatagi *et al.*, 1998) [34]. Field experiment conducted on a Vijayapura soil series confirmed that application of nitrogen at 75 kg ha^{-1} resulted in significantly higher productive tillers $plant^{-1}$ (4.95) as compared with the respective doses of nitrogen in finger millet (Somasundra *et al.*, 2004) [79]. Application of 60 kg ha^{-1} nitrogen recorded significantly higher productive tillers (3.7 $plant^{-1}$), number of earheads (6.7 $plant^{-1}$) and test weight (4.5 g) which was on par with 40 kg ha^{-1} nitrogen application in finger millet (Yadav *et al.*, 2010) [86]. Significantly higher number of productive tillers (3.0 $plant^{-1}$), earhead length (9.0 cm) and number of fingers (8.7 $earhead^{-1}$) under 150 per cent recommended dose of fertilizers than recommended dose of fertilizers in finger millet (Sandhya Rani *et al.*, 2017) [72]. Nagarajan *et al.* (2018) [48] found that application of 150 per cent RDN registered significantly more number of productive tillers (194 m-2), length of finger (6.4 cm), number of grains per earhead (1806), earhead weight (6.6) and test weight (3.7 g) in finger millet. Yadav *et al.* (2019) [87] noted that nitrogen management through basal dose + N through LCC recorded significantly higher number of cobs $plant^{-1}$ (1.36), cob length (21.5 cm), cob width (12.9 cm), grain rows cob^{-1} (14.67), number of grains row^{-1} (39.4) and 100 seed weight (26.7 g).

Effect of nitrogen levels on yield

The grain (4102 kg ha^{-1}) and straw yields (6988 kg ha^{-1}) were significantly increased with 60 kg N ha^{-1} and it was on par with 90 kg N ha^{-1} in finger millet on sandy soils at Agricultural College Farm, Bapatla (Mutyalu *et al.*, 1992) [47]. The grain and straw yields were increased significantly with an increase in nitrogen levels and 120 kg N ha^{-1} produced significantly higher grain and straw yields compared to all other lower levels including the control treatment (Chavan *et al.*, 1995) [6]. Application of 50 kg N ha^{-1} significantly increased grain (748 kg ha^{-1}) and straw yields (1769 kg ha^{-1}) in finger millet on shallow black soils at Regional Research Station, Bijapur (Kalaghatagi *et al.*, 1998) [34]. Similarly, higher grain (1183 kg ha^{-1}) and straw yields (2035 kg ha^{-1}) of finger millet were recorded with the application of nitrogen at 60 kg ha^{-1} compared to other treatments at Birbhum, West Bengal on clay loam soils (Roy *et al.*, 2002) [70]. Ramesh *et al.* (2002) [61] reported that the combined application of phosphobacteria at pre-planting along with recommended level of phosphorus (62.5 kg/ha) as rock phosphate and incorporation of intercropped daincha at 45 days after sowing in combination with recommended N and K (275 and 112.5 kg/ha) resulted in higher cane and sugar yields of 122.96 t/ha and 17.31 t/ha, respectively. Significantly higher mean yield of finger millet was recorded under application of 60 kg ha^{-1} nitrogen, which was on par with 40 kg nitrogen application in finger millet (Yadav *et al.,* 2010) [86].

Similarly, application of 150 per cent recommended dose of fertilizers recorded significantly higher grain yield of 3.21 t ha^{-1} and straw yield of 6.65 t ha^{-1} over recommended dose of fertilizers in finger millet (Sandhya Rani *et al.,* 2017) [72]. Significantly higher grain yield (22.25 q ha^{-1}) and straw yield (94.45 q ha^{-1}), were observed under application of 125% RDN (Recommended dose nitrogen). This might be due to the fact that nitrogen led to higher availability of nutrient that promoted growth and development and ultimately resulting in increasing yield attributes. Application of nitrogen fertilizer provides greater and prolonged availability of nutrients to the crop (Chouhan *et al.,* 2015) [9]. Ambika *et al.* (2017) [3] opined that application of 90:45:45 NPK kg ha^{-1} (50% inorganic and 50% organics) recorded significantly higher seed cotton yield (2834 kg ha^{-1}). Ramesh and Rathika (2017) [64] reported that the highest grain yield of rice recorded under GM + 100% N and it was statistically on par with GM + 75% N, 25% of nitrogen could be saved through green manuring. Nagarajan *et al.* (2018) [48] found that in nitrogen management, significantly higher grain and straw yields (3604 and 6740 kg ha^{-1}) were recorded under application of 50 per cent RDN than lower doses of nitrogen. This was due to due to higher level of nitrogen application would have improved the plant height, number of tillers and leaf chlorophyll content which resulted in more photosynthates accumulation and more yield attributes and ultimately higher grain and straw yields. Yadav *et al.* (2019) [87] opined that maximum biological (193.5 q ha^{-1}), grain (67.4 q ha^{-1}) and stover yield (126.1 q ha^{-1}) was recorded with nutrient application through basal+ N through LCC.

Effect of nitrogen levels on nutrient uptake

In irrigated finger millet, the uptake of N increased linearly from tillering and was highest at maturity. Among the levels of N, uptake of N, P and K was highest at 80 kg ha^{-1} and 120 kg ha^{-1} in *Rabi* and *Kharif* seasons, respectively (Rao *et al.,* 1991) [66]. Significantly higher N uptake was observed with 90 kg N ha^{-1} on sandy soils at Hisar during *Kharif* season (Harbirsingh *et al.,* 2006) [23]. Similarly, Kadalli *et al.* (2006) [33] reported that application of 100 per cent N, P and K integration with FYM recorded significantly higher nitrogen uptake (117.85 kg ha^{-1}) in *Kharif* season on sandy clay loam soils at GKVK, Bangalore. Similar results were also obtained by Duryodhana *et al*. (2004) [17] at GKVK, Bangalore on sandy loam soils. Sweeney *et al.* (2018) [80] stated that nitrogen uptake was determined as the product of dry matter and total N concentration. Pasley *et al.* (2019) [53] stated that nitrogen fertilizer increased plant uptake of P, S, Cu, and Zn by up to 280, 320, 420, and 210 per cent.

Effect of nitrogen levels on economics

Application of nitrogen at 60 kg ha^{-1} markedly improved net returns (Rs. 3295 ha^{-1}) in finger millet (Dubey and Shrivas, 1999). Increasing nitrogen levels, 40 kg nitrogen recorded higher BC ratio of 1.85 followed by 60 kg (1.67) nitrogen application in finger millet (Yadav *et al.,* 2010) [86]. Ramesh and Rathika (2017) [64] reported that green manure + 100% N gave higher gross returns (Rs.1,07,970/ha), net returns (Rs.60,324/ha) and BC ratio (2.3) followed by green manure + 75% N which gave gross returns of Rs.1,05,682/ha, net returns of Rs.58,651/ha and BC ratio (2.2) in rice. Application of 150 per cent recommended dose of fertilizers recorded higher BC ratio of 2.64 than other doses in finger millet (Sandhya Rani *et al.,* 2017) [72].

References

1. Allolli T, Hulihalli U, Athani S. Influence of in situ moisture conservation practices on the performance of dryland cluster bean. Karnataka Journal of Agricultural Sciences. 2008; 21(2):250–252.
2. Amanullah Yasir M, Khan AZ, Jan TM. Phenology, growth, and grain yield of maize as influenced by foliar applied urea at different growth stages. Journal of Plant Nutrition. 2016; 33:71-79.
3. Ambika V, Yadahalli GS, Chittapur BM, Shamrao Kulkarni G, Vidyavathi, Yadahalli *et al*. Influence of Land Configuration and Nutrient Levels on Soil Moisture and Yield of Bt Cotton Under Rainfed Situation. Indian Journal of Pure & Applied Biosciences. 2017; 5(6):396-401.
4. Ashok K, Rana DS. Effect of land configuration and weed management on weed suppression, nutrient depletion by weeds, yield, quality of rainy season groundnut (*Arachis hypogaea*). Indian Journal of Agricultural Sciences. 2004; 74(12):680-682.
5. Babu AM, Chandrika V, Reddy KS. Effect of nitrogen fertilization on yield of finger millet (*Eleusine coracana*) varieties under rainfed conditions. The Andhra Agricultural Journal. 2003; 50(1):6–9.
6. Chavan AP, Chavan SA, Khanvilkar SA. Response of finger millet to nitrogen, methods of fertilizer application and age of seedlings at transplanting. Journal of Maharashtra Agricultural University. 1995; 20(3):466–467.
7. Chavan SR. Impact of in-situ moisture conservation measures in maize - chickpea sequence cropping in vertisol of model watershed in Dharwad district. M.Sc. Thesis. Department of Agronomy, University of Agricultural Sciences, Dharwad, 2011.
8. Choudhary VK, Kumar PS, Bhagawati R. Response of tillage and insitu moisture conservation on alteration of soil and morpho-physiological differences in maize under Eastern Himalayan region of India. Soil & Tillage Research. 2013; 134:41–48.
9. Chouhan M, Dinesh kumar NN, Gudadhe, Vivek Kumar Singhal, Hanwat R. Productivity, quality and nutrient uptake by summer pearl millet as influenced by transplanting dates and Nitrogen levels. The Ecoscan. 2015; 8(Special issue):325-329.
10. CPG. Crop Production Guide. Department of Agriculture, Govt. of Tamil Nadu, Chennai and Tamil Nadu Agricultural University, Coimbatore, 2012.
11. CRIDA. Central Research Institute for Dryland Agriculture, Hyderabad, Annual Report, 2009-2010.

12. Desai NC, Adreshana RB, Intwala CG. Increasing pigeonpea productivity by providing land configuration in vertisols. International Chickpea and Pigeonpea Newsletter, 2000, 66-67.
13. Deshmukh SP, Patel JG, Patel AM. Ensuing economic gains from summer pearl millet (*Pennisetum glaucum* L.) due to different dates of sowing and land configuration. African Journal of Agricultural Research. 2013; 8(48):6337–6343.
14. Devaranavadgi VS, Bosu SS. Effect of in-situ moisture conservation practices in deep clay soils on growth and yield of maize (*Zea mays* L.) under rainfed condition. Karnataka Journal of Agricultural Sciences. 2014; 27(4):507–510.
15. Dhakad SS, Agrawal V, Verma S. Effect of ridge and furrow system on the growth character and productivity of rainfed soybean in Vidisha district of Madhya Pradesh. Research on Environment Life Science. 2014; 7(3):211–212.
16. Dubey O, Shrivas DN. Response of finger millet (*Eleusine coracana*) genotypes to nitrogen. Indian Journal of Agronomy. 1999; 44(3):564–566.
17. Duryodhana D, Gowda K, Kadalli G, Ashok EG. Uptake pattern of major nutrients at different growth stages by dry land finger millet (*Eleusine coracana* (L) Gaertn.) from different sources and levels of nutrients. Mysore Journal of Agricultural Science. 2004; 38(4):487–495.
18. Elamathi S. Effect of fertilizer and moisture conservation practices on rainfed sorghum in vertisols. In: 32nd crop scientists meet, Millets and forage crops, progress report 2013-14, TNAU, Coimbatore, 2014, 118–124.
19. Epstein M, Bloom AJ. Mineral nutrition of plants principles and perspectives. M. A. Sunderland, Sinauer, and Associates, Eds. (2nd Edition), 2005.
20. Gnanasoundari P, Balusamy M. Evaluation of land configuration and mulching on soil moisture retention and yield of rainfed cotton. Popular Kheti. 2015; 3(3):161-163.
21. Guo C, Li P, Lu J, Ren T, Cong R, Li X. Application of controlled release urea in rice reducing environmental risk while increasing grain yield and improving nitrogen use efficiency. Communications in Soil Science and Plant Analysis. 2016; 47:1176–1183.
22. Hanamant M Halli, Angadi SS. Influence of land configuration on rain water use efficiency, yield and economics of cowpea (*Vigna unguiculata* L.) in maize-cowpea sequence cropping under rainfed condition of Northern Transitional Zone. Legume Research. 2019; 42:211-215.
23. Harbirsingh RT, Hooda, Rakeshkumar, Singh V, Kumar V. Grain yield and nitrogen uptake by rainfed pearl millet (*Pennisetum glaucum* L.) hybrids under varying nitrogen application. Crop Research, 2006; 31(1):30–32.
24. Huber DM, Thompson MI. In: Nitrogen and plant disease. (W. H. Datnoff, Elmer, and D. M. Huber, Eds.), 2007, 31-44.
25. ICRISAT. International Crops Research Institute for the Semi-Arid Tropics, Hyderabad, Annual Report, 1977-1978.
26. Ingole BM, Bhakare AH, Paslawar AN, Gade RM. Effect of gypsum and zinc sulphate on yield and quality of summer groundnut under broad bed and furrow system. Journal of Soils and Crops, 1998; 8(1):64–66.
27. Jadhav JA, Patil DB, Ingole PG. Effect of mechanization with different land configuration on yield and in situ moisture conservation of soybean. International Journal of Agricultural Sciences. 2012; 8(1):2012.
28. Jat HS. Effect of layout, post-monsoon irrigation and fertilizers on pigeon pea (*Cajanus cajan* L.). IARI, New Delhi, 1999.
29. Jat HS, Ahlawat IPS. Effect of land configuration, post-monsoon irrigation and fertilizer application on pigeon pea (*Cajanus cajan* L.). Agronomy Digest. 2001: 1:52–55.
30. Jat RA, Arvadia MK, Tandel B, Patel TU, Mehta RS. Response of saline water irrigated greengram (*Vigna radiata*) to land configuration, fertilizers and farm yard manure in Tapi Command area of South Gujarat. Indian Journal of Agronomy. 2012; 57(3):270–274.
31. Jayapaul P, Udayakumar B, Devasagayam MM, Pandian BJ, Palchamy A, Balkrishnan A. Effect of land configuration methods, irrigation regimes and soil moisture conservation amendments on soybean (*Glycine max* (L.) Merr.) yield and quality characters. Crop Research. 1996; 10(3):253-257.
32. Joshi JR, Patel VM, Barad HL, Macwan SM, Ehsas J. Effect of land configuration and fertilizer management practices on growth, yield and yield attributes and economics of summer cowpea (*Vigna unguiculata* L.) under South Gujarat condition. International Journal of Current Microbiology and Applied Science. 2018; 7(1):1148–1155.
33. Kadalli GG, Duryodhana D, Ashok EG, Kirankumar VM, Gowda KKS. Efficacy of agrimagic, FYM and inorganic fertilizers in enhancing the productivity of selected dry land crops. Crop Research. 2006; 31(2):237–241.
34. Kalaghatagi SB, Jirali DI, Wali SY, Nagod MS. Response of finger millet to nitrogen and phosphorus under rainfed conditions. Karnataka Journal of Agriculture Sciences. 1998; 11(2):490–491.
35. Kalhapure AH, Shete BT. Response of rainfed sorghum (*Sorghum bicolor*) to moisture conservation techniques and sowing dates in rabi season. Karnataka Journal of Agriculture Sciences. 2013; 26(4):502–505.
36. Kantwa SR, Ahlawat IPS Gangaiah B. Performance of sole and intercropped pigeon pea (*Cajanus cajan*) as influenced by land configurations, post-monsoon irrigation and phosphorus fertilization. Indian Journal of Agricultural Sciences. 2006; 76(10):635–637.
37. Kiran JA, Lingaraju BS. Effect of in-situ moisture conservation practices and nitrogen levels on growth and yield of rabi sorghum in vertisols under rainfed condition. Karnataka Journal of Agriculture Sciences. 2005; 18(2):294–296.
38. Kumar I, Meena RN, Meena AK, Meena MK. Growth, yield and economics of pearl millet (*Pennisetum glaucum* L.) under custard apple (*Annona squamosa* L.) influenced by land configuration practices. Journal of Pharmacognosy and Phytochemistry. 2018; 7(5):3425-3428.
39. Lakpale R, Tripathi VK. Broad-bed furrow and ridge and furrow method of sowing under different seed rates of soybean (*Glycine max* L.) for high rainfall areas of Chattisgarh plains. Soybean Research. 2012; 10:52–59.
40. Lal M, Bora K, Ramesh V, Yadav P. Effect of in-situ moisture conservation on productivity of pearl millet in arid regions of Rajasthan under farmer's conditions. Annals of Arid Zone. 2007; 46(1):91–93.

41. Li QQ, Zhou XB, Chen YH, Yu SL. Seed yield and quality of winter wheat in different planting patterns under deficit irrigation regimes, Plant, Soil and Environment. 2010; 56:482-487.
42. Menon SQ, Mirza BB, Mari GR. Tillage practices and effect of sowing methods on growth and yield of maize crop. Agricultura Tropica Et Subtropica. 2007; 40(3):89-100.
43. Mishra A, Patra SS, Patnaik RN. Response of ragi (*Eleusine coracana* (L.) Gaertn.) to spacings and nitrogen. Indian Journal of Agronomy. 1973; 18:265–268.
44. Mudalagiriyappa B, Raghavendra G, Ramachandrappa BK, Nanjappa HV. Influence of customized fertilizers on growth and yield of finger millet (*Eleusine coracana* (L.) Gaertn.) in Alfisols of Southern India. Indian Journal of Dryland Agricultural Research and Development. 2015; 30(1):50-54.
45. Muralidaran C, Solaimalai A. A study on land configuration methods, row spacing and time of nitrogen application on nutrient uptake and yield of cotton in dryland condition of Western Zone of Tamil Nadu. Karnataka Journal of Agriculture Sciences. 2005; 18(1):1–3.
46. Muthamilselvan M, Manian R, Kathirvel K. In-situ moisture conservation techniques in dryfarming - a review. Agricultural Reviews. 2006; 27(1):67–72.
47. Mutyalu G, Venkateswarlu B, Bhanuprasad V. Influence of irrigation regimes and yield attributing characters of finger millet (*Eleusine coracana*). The Andhra Agricultural Journal. 1992; 39(3and4):189–192.
48. Nagarajan G, Ramesh T, Janaki P, Rathika S. Enhancement of finger Millet productivity through land configuration and nitrogen management under sodic soil. Madras Agricultural Journal. 2018; 105(7-9):257-261.
49. Nagdeote VG, Mangala G, Mhaske AR, Balpande SS, Ghodpage RM. Effect of land configuration, plant population and nitrogen management on productivity of sweet corn in vertisol. International Journal of Agricultural Sciences. 2016; 8(61):3428-3433.
50. Nicou R, Charreau C, Chopart JL. Tillage and soil physical properties in semi-arid West Africa. Soil & Tillage Research. 1993; 27(1–4):125–147.
51. NICRA. Evaluation of in-situ water harvesting technologies for dry land crops, water harvesting technology to cope with climate variability in dry land agriculture in Tamil Nadu. Progress Report 2013-2014, TNAU, Coimbatore, 2014, 201-202.
52. Parihar CM, Rana KS, Parihar MD. Crop productivity, quality and nutrient uptake of pearl millet (*Pennisetum glaucum*) and Indian mustard (*Brassica juncea*) cropping system as influenced by land configuration and direct and residual effect of nutrient management. Indian Journal of Agricultural Sciences. 2009; 79(1):927–930.
53. Parihar CM, Rana KS, Jat ML, Jat SL, Parihar MD, Kantwa SR *et al*. Carbon footprint and economic sustainability of pearl millet-mustard system under different tillage and nutrient management practices in moisture stress conditions. African Journal of Microbiology Research. 2012; 6(23):5052-5061.
54. Paslawar AN, Deotalu AS. Impact of soil moisture conservation practices and nutrient management under high density planting system of cotton. Indian Journal of Environmental Sciences. 2015; 4(9):34–36.
55. Pasley HR, Cairns JE, Camberato JJ, Vyn TJ. Nitrogen fertilizer rate increases plant uptake and soil availability of essential nutrients in continuous maize production in Kenya and Zimbabwe. Nutrient Cycling in Agroecosystems. 2019; 115:373–389.
56. Patel JG, Patel DD, Patel DK, Kumar V. Influence of depth of tillage and land configuration on yield and nutrient uptake by cotton cv. G.cot.hy.12 under South Gujarat condition. AGRES - An International e-Journal. 2013; 2(1):97–100.
57. Patel JG, Uoadhyay PN, Kumar V. Effect of depth of tillage and land configuration on yield and quality of cotton (*Gossypium hirsutum* L.) under South Gujarat condition. Journal of Research and Development. 2009; 23(1):64–67.
58. Patil DB, Mendhe S, Kolte H, Sathe H. Effect of land configuration and irrigation management on yield attributes and economics of linseed. Journal of Soils and Crops. 2011; 21(1):86–89.
59. Patil SL, Sheelavantar MN. Effect of moisture conservation practices, organic sources and nitrogen levels on yield, water use and root development of rabi sorghum in the vertisols of semi-arid tropics. Annals of agricultural research. 2000; 21(1):32–36.
60. Patil SL, Sheelavantar MN. Effect of cultural practices on soil properties, moisture conservation and grain yield of winter sorghum (*Sorghum bicolor* L. Moench) in semi-arid tropics of India. Agricultural Water Management. 2004; 64:49–67.
61. Ramesh T, Chinnusamy C, Jayanthi C. Integrated nitrogen and phosphorus mangement on productivity and profitability of early planted sugarcane (cv. CO. 86032). Indian Sugar. 2002; 52(2):99-104.
62. Ramesh T, Devasenapathy P. Physiological response of cowpea in a rainfed alfisol ecosystem to the impulse of soil moisture conservation practices. General and Applied Plant Physiology. 2006; 32(3–4):181–190.
63. Ramesh T, Rathika S. Land configuration techniques for rainfed Alfisols ecosystem- review. Green Farming. 2009; 2(12):879–881.
64. Ramesh T, Rathika S. Optimization of nitrogen dose for green manure incorporated rice under sodic soil. Madras Agricultural Journal. 2017; 104(7-9):221-225.
65. Rao RS, Reddy GV, Reddi GHS. Performance of finger millet genotypes under varying levels of nitrogen. Indian Journal of Agronomy. 1984; 29(3):408–410.
66. Rao RS, Subramanian S, Palaniappan SP. Effect of moisture regimes and nitrogen on NPK uptake and yield of finger millet. Madras Agricultural Journal. 1991; 78(9-12):388–391.
67. Rathore RS, Singh R, Nawange DD. Effect of land configuration on growth and yield of black gram. Legume Research. 2010; 33(4):274–278.
68. Reddy MG, Reddy SR, Reddy PR, Subrahmanyam K, Subrahmanyam MV. Effect of nitrogen on nitrogen and phosphorus uptake of finger millet. Indian Journal of Agronomy. 1986; 31(1):29–32.
69. Reddy BS, Maruthi V, Adake RV, Madal UK. Effect of Different Land configuration Practices on Productivity of Sorghum – Pigeonpea intercropping system in Shallow Alfisols. Indian journal of dryland agricultural research & development. 2009; 24(1):57-62.
70. Roy DK, Chakraborty T, Sounda G, Maitra S. Growth and yield attributes of finger millet as influenced by plant

population and different levels of nitrogen and phosphorus. Indian agriculturist. 2002; 46(1):65–71.
71. Saha A, Samanta S. Effect of land configuration and nutrient management on growth and yield of organic guar gum. Environment and Ecology. 2017; 35(2):799–801.
72. Sandhya Rani Y, Triveni U, Tssk P, Anuradha N. Effect of nutrient management on yield and quality of finger millet (*Eleusine coracana* (L.) Gaertn). International Journal of Chemical Studies. 2017; 5(6):1211–1216.
73. Selvaraju R, Balasubramanian T. Effect of moisture conservation practices on water use, micro climate and productivity of intercropping in dryland Vertisols. Journal Agricultural Physics. 2001; 1(1):112–116.
74. Selvaraju R, Subbian P, Balasubramanian A, Lal R. Land configuration and soil nutrient management options for sustainable crop production on alfisols and vertisols of southern peninsular India. Soil & Tillage Research. 1999; 52:203–206.
75. Sharma B, Kumari R, Kumari P, Meena SK, Singh RM. Evaluation of pearl millet (*Pennisetum glaucum* L.) performance under different planting methods at Vindhyan Region of India. Advances in Bioresearch. 2018; 9(3):123-128.
76. Singh P, Verma RS, Singh P. Nitrogen uptake and quality of pearl millet as influenced by moisture conservation practices and N fertilization. Indian Journal of Soil Conservation. 1996; 24(1):85–89.
77. Singh AK, Meena RN, Ravi Kumar A, Sunil Kumar, Meena R, Hingonia K, Singh AP. Effect of land configuration methods and sulphur levels on growth, yield and economics of Indian mustard [*Brassica juncea* L.] under irrigated condition. Journal of Plant Development Sciences. 2017; 9(1):29-33.
78. Somasundaram E, Ali AJ, Manoharan ML, Arokiaraj A. Response of crops to different land management practices under sodic soil conditions. Indian Journal of Agronomy. 2000; 45:92–96.
79. Somasundra KM, Siddaramappa R, Girish MA, Ravi MV. Response of finger millet to levels of N and K in Vijayapura soil series of Karanataka. Mysore Journal of Agricultural Science. 2004; 38(2):145–148.
80. Sweeney DS, Dorivar Ruiz-Diaz, Douglas J. Jardine. Nitrogen Management and Uptake by Corn on No-Till and Ridge-Till Claypan Soil. Agrosystems, Geosciences & Environment. 2018; 1:180034.
81. Thakur NS, Kushwaha BB, Sinha NK. Productivity and water use in Kharif sorghum (*Sorghum biclolor*) under different land configurations and mulching. Indian Journal of Agronomy. 2011; 56(1):47–51.
82. Tomar SS, Dwivedi A, Singh A, Singh MK. Effect of land configuration, nutritional management module and biofertilizer application on performance, productivity and profitability of urdbean [*Vigna mungo* (L.) Hepper], in north-western India. Legume Research. 2016; 39(5):741–747.
83. Tumbare AD, Bhoite SU. Effect of moisture conservation techniques on growth and yield of pearl millet-chickpea cropping sequence in a watershed. Indian Journal of Dryland Agricultural Research and Development. 2003; 18(2):149–151.
84. Vaghasia PM, Khanpara VD, Mathukia RK. Impact of in-situ moisture conservation and sulphur nutrition on yield, quality and nutrient uptake by groundnut. International Journal of Agricultural Sciences. 2007; 3(1):151–153.
85. Vekariya PD, Sanepara DP, Limbasia BB, Sharma GR, Akbari KN. Effect of different size of broad bed and furrow on runoff and soil loss and productivity of groundnut (*Arachis hypogea* L.) under rainfed conditions. International Journal of Bio-Resource and Stress Management. 2015; 6(3):316–321.
86. Yadav R, Malik N, Yadav VK. Response of finger millet (*Eleucine coracana* (L.) Gaertn) genotypes to nitrogen under rainfed situations of western Himalayan hills. International Journal of Agricultural Sciences. 2010; 6(1):325–326.
87. Yadav AC, Husain K, Verma VK, Tiwari US, Khan N, Siddiqui MZ. Effect of land configuration and nutrient management on growth and yield of hybrid maize. Journal of Pharmacognosy and Phytochemistry 2019; 8(4):602-606.