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Effect of different land configuration and nutrient management on nutrient uptake and yield of soybean

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Abstract
A field experiment was carried out during 2016- 17 and 2017- 18 at Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, to study the performance of soybean-safflower cropping sequence under different land configuration and nutrient management. Treatment consists of eighteen treatment combinations comprising three land configuration (L_1- flat beds, L_2- ridges and furrow and L_3- Broad bed furrow) and three superabsorbent levels (S_1- 0 Kg ha^{-1}, S_2- 2.5 Kg ha^{-1} and S_3- 5.0 Kg ha^{-1}) in main plot, two nutrient levels *i.e.,* N_1 - 30:60:30 NPK kg ha^{-1} + 5 t FYM ha^{-1} and N_2 - 30:60:30:30 NPKS kg ha^{-1} + 20 kg Zn SO_4 + 5 t FYM ha^{-1} to soybean during *kharif* as sub plot treatments were assigned in a split plot design with three replication. Broad bed furrows planting method with the application of 30:60:30:30 NPKS kg ha^{-1} + 20 kg Zn SO_4 + 5 t FYM ha^{-1} to soybean during *kharif season* recorded significantly higher nutrient uptake *viz.* N, P, K, S and Zn as well as soybean yield during both the year of study.

Keywords: Broad bed furrows, N, P, K, S and Zn uptake and yield

Introduction
Oilseed crops are sources of fats and oils, which are essential for human diet, comprising about 40% of the calories in the diet of the average person. India is amongst the largest producer and consumer of vegetable oils in the World. Oilseeds have been the backbone of agricultural economy of India since long. Indian vegetable oil economy is the fourth largest in the world next to USA. China and Brazil. Oilseed crops play the second important role in the Indian agricultural economy next to food grains in terms of area and production. India holds the first position in the world with an area of 26.4 m ha under oilseed cultivation, producing 30 m t (Economic survey. 2016-2017). India's average oilseeds yield is 1135 kg ha^{-1}which is very low as compared to world's average yield of 2000 kg ha^{-1}.

Among the edible oilseeds, soybean [*Glycine max* (L.) Merrill.] is the leading oilseed crop in the world with an area of 145 m ha. In India too, it is the most important oilseed crop with an area of 12 m ha and a production of 12.23 m t with an average productivity of 1017 kg ha (http: '.Avww.sopa.org). Some of the major limiting factors for low productivity of soybean are limiting moisture conditions as this is mostly grown under rain fed conditions during *kharif.* The imbalanced and inadequate fertilization is also found to be one of the major limiting factors for its poor yield.

The population growth scenario, predicts that by 2025 India will have 1.4 billion population requiring 301 million tons of food. According to Lester Brown and Kene of the World Watch Institute, 1994, India may have to import 40 Mt food grains by 2025 if the present growth rate of agriculture and population continues. This also seems to be an under estimate, as the present agricultural growth rate of 2.9 per cent cannot sustain by itself. Further, the demographic projections of India indicated that the per capita land availability from 0.14 ha in the year 2000 will be reduced to 0.10 ha by the year 2025. Moreover, besides the shrinking land area, the quality of land likely to remain available for agriculture will be poor due to severe competition from urbanization, industrialization and civic needs. Therefore, horizontal expansion to augment the food production is limited and the alternative way is to move on vertical growth by enhancing the productivity of the area. Hence, focusing the attention on sequential cropping, increasing the cropping intensity as well as production per unit area per unit time is now gaining ground for improved production (Kanwar and Sekhon, 1998) [14].

Food production must increase in order to cope with the expected population increase, while at the same time addressing pertinent global challenges such as environmental degradation and climate change. Overall, action is acutely necessary to resolve today's problems in order to prevent them from becoming tomorrow's catastrophes

Soybean is grown as major *Kharif* crop in the Marathwada region. Soybean based cropping system has attained, a great significance in terms of area, production and productivity, particularly in west-central region of India. Majority of the area covered under this cropping systems confined to rainfed farming situations belongs to Vertisols and associated soils (Bhatnagar and Joshi, 1999) [6]. These area, normally receives an average annual rainfall of 800-1000 mm, which is mostly erratic and undependable, causes excess or deficient moisture conditions during one or other stage of crop growth. Therefore, the yield of rainfed soybean is often low and erratic. The fluctuation in yield is mainly due to shortage and ill distribution of rainfall in *kharif* season and the low infiltration rate of soil.

In recent years, uncertainties in rainwater availability, the swings in the onset, continuity and withdrawal pattern of monsoon has made crop production more risky in rainfed areas (Singh, 2000) [27]. Under these circumstances, efficient rainwater management practices act as insurance for crops during abnormal rainfall situation. Drought stress is one of the major limiting factor that affect crop growth and productivity.

For getting a sustainable crop production system under rainfed condition, the conservation of rainwater and its efficient recycling are imperative. Among the various land configuration practices flat bed, ridges and furrow and broad bed furrow developed systems are very promising in controlling surface runoff, reducing the soil loss through erosion and increasing infiltration. Land configuration plays an important role in conservation of maximum water in the soil. Chittaranjan (1981) [7]. stated that land configuration is the mechanical measure for better *in situ* moisture conservation as the soil profile acts as reservoir for moisture storage and this facility needs to be exploited to the maximum extent. Efficient management of soil moisture is important for agricultural production in the light of scarce water resources. Super absorbent polymers are used to reduce the impact of water stress during crop growth and development. These are made of hydrocarbon and can absorb and retain water several times of their weight. These absorbent contribute significantly to provide a reservoir of soil water to plants on demand in the upper layers of the soil where the root systems normally develop. The polymeric organic materials as super absorbent apart from improving the soil physical properties also serve as buffers against temporary drought stress and reduce the risk of plant failure during establishment. This is achieved by means of reduction of evaporation through restricted movement of water from the sub-surface to the surface layer. Drought stress is a key limiting factor leading to lower crop yields, especially in the late growing season of winter crops because there is not enough precipitation during the spring months.

Reddi and Reddi (1995) [19], indicated that, in many parts of the world, water is the major factor limiting crop production because water shortage affects several plant physiological processes (Sinaki *et al.*, 2007) [26].

Therefore, production technology and management practices should be developed keeping in view all the above point, for efficient use of costly inputs, beside reduction in production cost, for instance residual effect of manures and fertilizers applied and nitrogen fixed by legumes can considerably bring down the production cost.

Material and methods

The field experiment was conducted at Department of Agronomy, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, during kharif and *rabi* season of 2016-17 and 2017-18. The soil of the experimental site was clayey in texture (54.18 % clay), alkaline in nature (pH 7.8) low in available nitrogen (219.48 kg ha^{-1}), medium in available phosphorus (17.32 kg ha^{-1}) fairly rich in available potassium (545.50 kg ha^{-1}) and medium in organic carbon (0.54 %). The topography of the experimental plot was fairly uniform and levelled. The experiment was comprised of a total of eighteen treatment combinations comprising three land configuration (L_1- flat beds, L_2- ridges and furrow and L_3- Broad bed furrow) and three superabsorbent levels (S_1- 0 Kg ha^{-1}, S_2- 2.5 Kg ha^{-1} and S_3- 5.0 Kg ha^{-1}) in main plot, two nutrient levels *i.e.,* N_1 - 30:60:30 NPK kg ha^{-1} + 5 t FYM ha^{-1} and N_2 - 30:60:30:30 NPKS kg ha^{-1} + 20 kg Zn SO_4 + 5 t FYM ha^{-1} to soybean during *kharif* season as sub plot treatments were assigned in a split plot design with three replication. Full dose of NPKS and Zn was applied as basal dose as per treatments to soybean. The crop was sown at a spacing of 45 × 5 cm on 25 June 2016 and harvested on 6 October 2016 during first year and during second year sown on 27 June 2017 and harvested on 13 October 2017. The various observation were recorded on five randomly selected soybean plants from net plots, which were tied tags for their easy identification. The experiment crop of soybean received 1116.7 mm rains over 66 rainy days and 994.10 mm rains over 52 rainy days respectively, during first and second year of experiment. The receipt of rainfall during *kharif* was 1126.7 mm and 994.10 mm in 66 and 52 rainy days during 2016-17 and 2017-18, respectively. The distribution of rainfall during first year was excess while it was deficit during second year. The wind velocity during the crop growth period ranged from 2.4 to 7.1 km hr^{-1} during 2016-17 and 2.90 and 8.0 km hr^{-1} during 2017-18. Treatment wise plant samples of soybean and safflower were collected. The plant was firstly cleaned by rinsing with detergent followed by 0.02 N HCl and deionised water. After cleaning the plant, they were air dried and oven dried at 70^0 C for 12 hours and they were ground in electrically operated stainless steel blades grinder up to maximum fineness. The ground samples were stored in polythene bags with proper labeling for chemical analysis. At harvest, dry matter and grain yields were recorded and these plant components were further used for chemical analysis (Bhargava and Raghupati, 2001) [5]. Total nitrogen concentration in plant was determined by Kjeldhal method (AOAC, 1975) [1]. Phosphorus contained in the extracts was estimated by reacting the extract with vanadomolybdate forming yellow colour complex in HNO_3 medium. The colour was developed in about 30 minute and the transmittance or absorbance of solution was read at colorimeter using blue filter (Jackson, 1967) [10]. For potassium the extract was diluted to appropriate concentration and was directly atomized to the flame photometer at 548 nm wavelength (Jackson, 1967) [10]. Sulphur in plant and grain samples was estimated by turbidimetric method as described by Tabatabai and Bremner (1972) [28]. The turbidity was measured on spectrophotometer. The total zinc from plant and grain samples was estimated from di-extract digest with proper dilution using Atomic Absorption Spectrophotometer with different wavelength after proper dilution (Jackson, 1973) [11]. Uptake of nutrients *i.e.* N, P, K, S and Zn was computed considering biological yield (*i.e.* grain and whole plant) and concentration of the particular nutrient.

$$\text{Uptake of nutrient (kg ha}^{-1}\text{)} = \frac{\text{Yield (kg ha}^{-1}\text{) x Nutrient content}}{100}$$

Results and Discussion

Yield of soybean

Seed yield of soybean showed remarkable improvement by adopting different land configuration method (Table 1). The broad bed furrows planting method was most efficient for increase in yield than flat bed planting but it was at par with the ridges and furrows. This might be owing to better availability of the physical condition of the soil and soil moisture after completion of vegetative growth, which contributed for more photosynthesis and translocation of photosynthates towards reproductive organs i.e. from source to sink, which resulted in higher yield. (Wadile *et al.*, 2017) [30]. More favoured overall growth and yield attributing characters may be due to favourable seed bed, better aeration, scope for more space, light interception, benefit of more conserved moisture in furrows and its support at critical growth stages like flowering, pod initiation and development which in turn resulted in higher yields of soybean crop. This results correlate with the work of Jaypaul (1996) [13], Jain *et al*., (2000) [12], and Raut *et al*., (2000) [18].

Application of 30:60:30:30 NPKS +20 kg $ZnSO_4$ + 5 t FYM ha^{-1} recorded significantly higher values of seed yield (2144 kg/ha) than of the applicaton 30:60:30 NPK + 5 t FYM ha^{-1}. This might be due to larger leaf area with this treatments. Larger leaf area resulted in more photosynthetic activities and more accumulation of carbohydrates which in turn increased dry matter accumulation. Similar results were also reported by Raut *et al.*, (2003) [17], Saxena *et al.*, (2003) [21], and More *et al.*, (2006) [15]. Soybean has been reported to be responsive to sulphur with respect to dry matter accumulation (Shivakumar and Ahlawat, 2008 and Prabhakaran and Lourduraj, 2003) [25, 16]. The application of zinc significantly increased the dry matter accumulation at all the stages except at 30 DAS (Awlad *et al.*, 2003 and Thenua *et al*., 2014) [2, 29].

Nutrient uptake

Studies on chemical analysis of plant indicated that the nutrient content and their uptake in seed and straw of soybean showed significant differences due to different land configuration. N, P, K, S and Zn content and uptake in seed and straw of soybean was higher under the broad bed furrows (L_3) planting over flat beds (L_1) and it was at par with the ridges and furrows (L_2). This might be attributed to better root growth due to better aeration, good drainage and good soil air movement might have also increased microbial activity with optimum moisture and nutrient availability for its growth causing more nutrient recovery through grain and stover under broad bed furrows. Such findings are in line with the investigation of Bharambe *et al.* (2004) [4], Shete *et al.* (2010) [23], and Shinde *et al.* (2013) [24].

The nutrient content *viz*. N, P, K, S and Zn in grain and straw of soybean and their uptake was enhanced due to nutrient management practices in soybean. The higher values of nutrient content (N, P, K, S and Zn) and their uptake were found under the treatments of 30: 60: 30: 30 NPKS+ 20 kg $ZnSO_4$+ 5 t FYM ha^{-1} (N_2) over 30: 60: 30 NPK+ 5 t FYM ha^{-1} (N_1) during the both the years of investigation. The higher values of uptake of nutrients were a result of higher grain and straw yield of soybean. The higher availability of N, P and K with the application of sulphur and zinc might have increased the uptake of N, P and K by soybean, which might be due to their mutually competitive effect on the adsorption sites on the colloidal surfaces and resulted in increase in their concentration in soil solution (Reddy and Reddy, 2001) [20]. Similar results have been reported by Bansal (1991) [3], Sharma and Gupta (1992) [22]. The above results revealed that S and Zn dose increased its uptake due to high S and Zn content and high seed and straw yield. These results in agreement with those of Ganeshmurthy (1996) [9].

Table 1: Seed and straw yield of soybean as influenced by different treatments

Treatments	Seed yield (kg ha^{-1})		Straw yield (kg ha^{-1})	
	2016- 17	2017- 18	2016- 17	2017- 18
Land configuration				
L_1- Flat bed	1961	1535	3028	2446
L_2- Ridges and furrow	2281	1806	3317	2703
L_3- Broad bed furrow	2434	1971	3428	2860
S.E. ±	58.59	71.51	59.63	72.43
C. D. (P=0.05)	175	214	178	216
Superabsorbent				
S_1- 0 kg ha^{-1}	2156	1684	3214	2614
S_2- 2.5 kg ha^{-1}	2217	1786	3243	2658
S_3- 5 kg ha^{-1}	2303	1842	3316	2738
S.E. ±	58.59	71.51	59.63	72.43
C. D. (P=0.05)	NS	NS	NS	NS
Nutrient management				
N_1- 30:60:30 NPK kg/ha + 5 t FYM /ha / 40:20:00 NPK kg/ha	2067	1638	3127	2547
N_2- 30:60:30:30 NPKS +20 kg $ZnSO_4$ + 5 t FYM/ha/ 30:15:00 NPK kg/ha	2384	1903	3389	2792
S.E. ±	36.81	36.24	29.78	40.18
C. D. (P=0.05)	109	107	88.49	119

Table 2: Nitrogen, phosphorus and potassium content (%) in soybean as influenced by different treatments during 2016-17

Treatment	Nitrogen		Phosphorus		Potassium	
	Seed	Straw	Seed	Straw	Seed	Straw
Land configuration						
L_1- Flat bed	5.41	1.05	0.46	0.18	1.63	0.66
L_2- Ridges and furrow	5.58	1.18	0.59	0.33	1.78	0.81
L_3- Broad bed furrow	5.68	1.24	0.65	0.39	1.85	0.87
S.E. ±	0.045	0.038	0.027	0.040	0.039	0.038
C. D. (P=0.05)	0.137	0.113	0.083	0.120	0.120	0.112
Super absorbent						
S_1- 0 kg ha^{-1}	5.53	1.14	0.55	0.27	1.74	0.76
S_2- 2.5 kg ha^{-1}	5.55	1.15	0.56	0.29	1.75	0.78
S_3- 5 kg ha^{-1}	5.60	1.18	0.59	0.33	1.78	0.80
S.E. ±	0.045	0.038	0.027	0.040	0.039	0.038
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS
Nutrient management						
N_1- 30:60:30 NPK + 5 t FYM ha^{-1}	5.49	1.09	0.50	0.23	1.70	0.72
N_2- 30:60:30:30 NPKS +20 kg $ZnSO_4$ + 5 t FYM ha^{-1}	5.62	1.22	0.63	0.36	1.81	0.84
S.E. ±	0.027	0.019	0.020	0.021	0.020	0.026
C. D. (P=0.05)	0.080	1.22	0.060	0.062	0.061	0.079

Table 3: Nitrogen, phosphorus and potassium content (%) in soybean as influenced by different treatments during 2017-18

Treatment	Nitrogen		Phosphorus		Potassium	
	Seed	Straw	Seed	Straw	Seed	Straw
Land configuration						
L_1- Flat bed	5.32	0.97	0.41	0.14	1.56	0.60
L_2- Ridges and furrow	5.50	1.09	0.54	0.28	1.70	0.76
L_3- Broad bed furrow	5.58	1.14	0.60	0.34	1.77	0.82
S.E. ±	0.057	0.03	0.035	0.038	0.040	0.038
C. D. (P=0.05)	0.173	0.09	0.107	0.113	0.120	0.112
Super absorbent						
S_1- 0 kg ha^{-1}	5.44	1.05	0.49	0.23	1.67	0.71
S_2- 2.5 kg ha^{-1}	5.45	1.06	0.51	0.25	1.68	0.72
S_3- 5 kg ha^{-1}	5.51	1.09	0.54	0.28	1.69	0.74
S.E. ±	0.057	0.03	0.035	0.038	0.040	0.038
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS
Nutrient management						
N_1- 30:60:30 NPK + 5 t FYM ha^{-1}	5.39	1.00	0.45	0.19	1.62	0.66
N_2- 30:60:30:30 NPKS +20 kg $ZnSO_4$ + 5 t FYM ha^{-1}	5.54	1.13	0.58	0.31	1.74	0.78
S.E. ±	0.027	0.02	0.018	0.019	0.020	0.019
C. D. (P=0.05)	0.080	0.06	0.054	0.057	0.060	0.056

Table 4: Sulphur (%) and zinc content (ppm) in soybean as influenced by different treatments during 2016- 17 and 2017- 18

Treatment	Sulphur (%)				Zinc (ppm)			
	2016-17		2017- 18		2016-17		2017- 18	
	Seed	Straw	Seed	Straw	Seed	Straw	Seed	Straw
Land configuration								
L_1- Flat bed	0.32	0.15	0.26	0.12	55.98	28.83	50.60	21.72
L_2- Ridges and furrow	0.46	0.28	0.40	0.24	63.90	36.64	59.60	31.53
L_3- Broad bed furrow	0.51	0.33	0.47	0.30	66.52	40.67	64.20	34.56
S.E. ±	0.03	0.03	0.03	0.02	1.81	2.09	2.31	1.79
C. D. (P=0.05)	0.10	0.11	0.09	0.08	5.42	6.28	6.92	5.37
Super absorbent								
S_1- 0 kg ha^{-1}	0.41	0.23	0.36	0.20	61.03	34.28	56.95	28.17
S_2- 2.5 kg ha^{-1}	0.43	0.25	0.38	0.22	62.31	35.56	58.21	29.45
S_3- 5 kg ha^{-1}	0.45	0.27	0.40	0.24	63.06	36.30	59.24	30.19
S.E. ±	0.03	0.03	0.03	0.02	1.81	2.09	2.31	1.79
C. D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Nutrient management								
N_1- 30:60:30 NPK + 5 t FYM ha^{-1}	0.37	0.20	0.31	0.16	58.72	31.97	54.80	25.86
N_2- 30:60:30:30 NPKS +20 kg $ZnSO_4$ + 5 t FYM ha^{-1}	0.49	0.30	0.44	0.27	65.55	38.79	61.46	32.68
S.E. ±	0.01	0.01	0.02	0.01	0.76	0.97	1.12	0.910
C. D. (P=0.05)	0.05	0.05	0.06	0.05	2.26	2.89	3.54	2.70

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