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Nutrient content as well as uptake of summer sesame as affected by nitrogen, phosphorus and biofertilizers under South Gujarat condition

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Abstract
The investigation entitled, "Nutrient content as well as nutrient uptake of summer sesame as affected by nitrogen, phosphorus and biofertilizers under south Gujarat condition" was conducted during summer season of 2016 at College Farm, Navsari Agricultural University, Navsari to study the response of summer sesame to nitrogen, phosphorus and biofertilizers. The different levels of nitrogen viz., N_1: 25 kg/ha, N_2: 50 kg/ha and N_3: 75 kg/ha, different levels of phosphorus P_1: 12.5 kg/ha, P_2: 25 kg/ha and P_3: 37.5 kg/ha and biofertilizers viz., B_0: No inoculation and B_1: Inoculation with azotobacter and phosphate solubilizing bacteria to summer sesame in eighteen treatment combinations replicated three in factorial randomized block design. Nutrient content (N, P and K) in seed and haulm was non-significant on nitrogen, phosphorus and biofertilizers. Nutrient uptake (N, P and K) by seed and haulm was significantly higher the application of N_3: 75 kg/ha and P_3: 37.5 kg/ha which was at par with N_2: 50 kg/ha and P_2: 25 kg/ha. Nutrient uptake (N and P) by seed was significantly highest the B_1: Inoculation with azotobacter and PSB, While, the K uptake by seed was non-significant. Nutrient uptake (N, P and K) by haulm was non-significant to B_0: No inoculation and B_1: Inoculation with azotobacter and PSB.

Keywords: Sesame, Nitrogen, phosphorus, biofertilizers, phosphate solubilizing bacteria, Nutrient content and uptake

Introduction
Oilseed crops play a vital role in the Indian agriculture, industry and export trade. In India, oilseed crops occupy an area of about 26.53 million hectares with the production of 31.01 million tonnes and average productivity of 1169 kg/ha (Anon., 2014) [1]. Sesame (*Sesamum indicum* L.) is variously known as sesamum, til, simsim, benised, gingelly, gergelim etc. It is known as "The queen of the oilseed crops" by virtue of the excellent quality of the oil, flavor, taste and softness. Its oil content generally varies from 46 to 52 per cent. It is eaten as raw or either roasted or parched and mixed in many kitchen items. Sesame seed is rich source of linoleic acid, vitamin E, A, B1, B2 and niacin and minerals including calcium and phosphorus. Sesame is cultivated over an area of more than 74.06 lakh ha in world with an annual production of 39.59 lakh tonnes and yield of 535 kg/ha (Anon., 2014).The area, production and productivity of this crop in Gujarat is 4.02 lakh hectares, 2.41 lakh tonnes and 598 kg/ha, respectively. (Anon., 2014) [1]. In Gujarat, Mahesana, Banaskantha, Sabarkantha, Kheda, Amreli, Bhavnagar, Junagadh and Surendranagar are the major districts in which sesame is cultivated. This crop is generally cultivated as sole or mixed crop during *kharif*, semi-*rabi* and now a day in summer season in all the districts of the state.
The area, production and productivity of sesame are higher in summer season than those of post *kharif* and *kharif* season, but the productivity of sesame in general is much lower than its potential yield. Lower productivity is due to use of sub-optimal rate of fertilizer, poor management and cultivation of sesame in marginal and sub-marginal lands, where deficiency of macronutrient such as nitrogen, phosphorus, potassium and micronutrient is predominant. Balanced fertilization with N and P is proved beneficial in all the oilseed crops to minimize the unfavourable exploitation of soil fertility and plant nutrient, thus maintain the soil health and plant nutrient at optimum level. Nitrogen, phosphorus and biofertilizers like *Azotobacter* and *phosphate solubilizing bacteria* play a vital role in the nutrition of plants. In fact, these fertilizer nutrients are lacking mostly in the soils. Fertility analysis of Indian soils has indicated that the soils are deficient in microorganisms and nutrients. Therefore, application of biofertilizers and inorganic fertilizers becomes essential to raise the crop yield.

Materials and Methods

The investigation entitled, "Nutrient content as well as nutrient uptake of summer sesame as affected by nitrogen, phosphorus and biofertilizers under south Gujarat condition" was conducted during summer seasons of 2016 at College Farm, Navsari Agricultural University, Navsari. The soil of the experimental field was clayey in texture and slightly alkaline in reaction (pH 7.6), organic carbon (0.57%) and available nitrogen (198.24 kg/ha), available phosphorus (30.87 kg/ha) and available potassium (372.81 kg/ha). The different levels of nitrogen viz., N_1: 25 kg/ha, N_2: 50 kg/ha and N_3: 75 kg/ha, different levels of phosphorus P_1: 12.5 kg/ha, P_2: 25 kg/ha and P_3: 37.5 kg/ha and biofertilizers viz., B_0: No inoculation and B_1: Inoculation with azotobacter and phosphate solubilizing bacteria to summer sesame in eighteen treatment combinations replicated three in factorial randomized block design. Plant samples of seed and haulm of sesame collected at harvest were ground in willey mill to pass through 40 mesh sieve. The ground material was collected in butter paper bags and later used for chemical analysis. Nitrogen, phosphorus and potassium content from seed and haulm were estimated using standard procedures given by Jackson [6]. The nutrient (NPK) uptake was worked out by using of nutrient content and biomass production data. The data on various variables were analysed by using statistical procedures as described by Panse and Sukhatme [10].

Results and discussion

The response of summer sesame to nitrogen, phosphorus and biofertilizers showed great impact on seed and haulm yields of sesame. Sesame crop produced significantly higher seed and haulm yields [Table-1] supplied through application N_3: 75 kg/ha. Amount of nitrogen plays an important role in plant metabolism by virtue of being an essential constituent of diverse types of metabolically active compounds like amino acids, proteins, nucleic acid, enzymes, co-enzymes and alkaloids which are important for higher seed and haulm yields of sesame. This increase in growth and yield attributes ultimately helped in realization of higher seed yield. The results obtained in this study are in agreement with those reported by Dinakaran *et al.* (2001) [3], Sarala and Jagannatham (2002) [13], Chaubey *et al.* (2003) [2], EL-Mahdi (2008) [4] and Patel *et al.* (2014) [11] in summer sesame.

The data given in Table 1 revealed that different levels of nitrogen, phosphorus and biofertilizers were not significantly influenced on nitrogen, phosphorus and potassium content in seed and haulm. The results in Table 2 showed that treatment N_3 (75 kg N ha^{-1}) significantly influenced the nitrogen (31.75 and 10.50 kg ha^{-1}), phosphorus (22.38 and 2.66 kg ha^{-1}) and potassium (9.59 and 11.69 kg ha^{-1}) uptake by seed and haulm. This increase in nitrogen uptake by seed and haulm might be due to cumulative effect of increased seed yield and haulm yield.

These results are in accordance with the results reported by Kene *et al.* (1991) [8] and Rao (1992) [12].

Application of phosphorus brought significant variation in seed and haulm yields of sesame table 1. The significant response in seed and haulm yield (967.75 and 1653.53 kg ha^{-1}) of sesame was obtained with application of P_3 (37.5 kg P_2O_5 ha^{-1}) to the tune of 0.27 and 11.19 per cent of seed yield and 6.19 and 9.45 per cent of haulm yield over P_2 and P_1, respectively. The increase in seed and haulm yield of sesame with higher level of phosphorus evidently resulted higher number of capsules per plant in Table 4.6. Higher seed yield under the treatment P_3 (37.5 kg P_2O_5 ha^{-1}) was also probably a consequence of greater amount of nutrients uptake table 2.

Among the phosphorus is a fascinating plant nutrient and involved in a wide range of plant processes from cell division to the development of good root system and ensuring timely and uniform ripening of the crop. It is needed mostly by young, fast growing tissues and performs a number of functions related to growth, development, photosynthesis and utilization of carbohydrates. It is constituent of ADP to ATP, two of the most important substances in life processes. These all processes favourably improved with higher rate of phosphorus and resulted into higher seed and haulm yield of sesamum. These results are in agreement with these reported by Jadhav *et al.* (1988) [7], Khade *et al.* (1996) [9], Thanki *et al.* (2004) [15] and Thakur *et al.*(2015) [14].

Table 1: Seed and haulm yields of sesame (kg/ha) and nutrient (NPK) content (%) in seed and haulm of sesame crop at harvest as influenced by different treatments

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	NPK content in seed			NPK content in haulm		
			N content (%)	P content (%)	K content (%)	N content (%)	P content (%)	K content (%)
Nitrogen levels								
N_1: 25 kg N ha^{-1}	806.38	1448.04	3.14	2.20	0.94	1.01	0.25	1.13
N_2: 50 kg N ha^{-1}	997.77	1633.77	3.18	2.21	0.94	1.02	0.26	1.14
N_3: 75 kg N ha^{-1}	999.10	1639.49	3.26	2.24	0.96	1.05	0.27	1.17
S.Em.±	26.62	37.82	0.03	0.02	0.01	0.01	0.00	0.01
C.D. at 5 %	79.09	112.38	NS	NS	NS	NS	NS	NS
Phosphorus levels								
P_1 : 12.5 kg P_2O_5 ha^{-1}	870.35	1510.77	3.15	2.21	0.94	1.01	0.26	1.14
P_2 : 25 kg P_2O_5 ha^{-1}	965.15	1557.00	3.17	2.21	0.94	1.02	0.26	1.14
P_3 : 37.5 kg P_2O_5 ha^{-1}	967.75	1653.53	3.26	2.23	0.96	1.05	0.27	1.16
S.Em.±	26.62	37.82	0.03	0.02	0.01	0.01	0.00	0.01
C.D. at 5 %	79.09	112.38	NS	NS	NS	NS	NS	NS
Biofertilizers inoculation								
B_0 : No inoculation	901.69	1527.01	3.18	2.21	0.94	1.03	0.26	1.15
B_1 : Inoculation with *Azotobacter* and *PSB*	967.14	1620.52	3.21	2.22	0.95	1.03	0.26	1.15
S.Em.±	21.74	30.88	0.03	0.01	0.01	0.01	0.00	0.01
C.D. at 5 %	64.58	91.76	NS	NS	NS	NS	NS	NS
Interaction								
N x P x B	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	12.09	10.20	4.45	3.17	3.89	4.07	4.77	3.42

The uptake of nitrogen, phosphorus and potassium by seed and haulm table 2 was remarkably influenced due to application of different levels of phosphorus. Significantly higher uptake of nitrogen by seed (30.75 kg ha^{-1}) and haulm (10.17 kg ha^{-1}), phosphorus by seed (21.68 kg ha^{-1}) and haulm (2.58 kg ha^{-1}) and potassium by seed (9.29 kg ha^{-1}) and haulm (11.29 kg ha^{-1}) were obtained under the treatment P_3 (37.5 kg P_2O_5 ha^{-1}), but it was remained statistically at par with uptake of nitrogen by seed (30.67 kg ha^{-1}) and haulm (9.91 kg ha^{-1}), phosphorus by seed (21.62 kg ha^{-1}) and haulm (2.50 kg ha^{-1}) and potassium by seed (9.27 kg ha^{-1}) and haulm (11.08 kg ha^{-1}) in treatment P_2 (25 kg P_2O_5 ha^{-1}). The increase in uptake of nitrogen in seed and haulm of sesamum due to application of 37.5 kg P_2O_5 ha^{-1} could be attributed to favourable effect of phosphorus application on growth and yield attributes which resulted in higher seed and haulm yield in Table 4.8 and consequently more removal of nitrogen by the seed and haulm. Similar results were also reported by Rao *et al.* (1993) [12] and Verma *et al.* (2013) [16].

Table 2: Seed and haulm yields of sesame (kg/ha) and nutrient (NPK) uptake (kg/ha) by seed and haulm of sesame crop at harvest as influenced by different treatments.

Treatments	Seed yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	NPK uptake in seed			NPK uptake in haulm		
			N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})	N uptake (kg ha^{-1})	P uptake (kg ha^{-1})	K uptake (kg ha^{-1})
Nitrogen levels								
N_1: 25 kg N ha^{-1}	806.38	1448.04	25.62	18.06	7.74	8.20	2.06	9.17
N_2: 50 kg N ha^{-1}	997.77	1633.77	31.70	22.35	9.58	10.25	2.59	11.45
N_3: 75 kg N ha^{-1}	999.10	1639.49	31.75	22.38	9.59	10.50	2.66	11.69
S.Em.±	26.62	37.82	0.85	0.60	0.26	0.36	0.09	0.39
C.D. at 5 %	79.09	112.38	2.51	1.77	0.76	1.08	0.28	1.16
Phosphorus levels								
P_1 : 12.5 kg P_2O_5 ha^{-1}	870.35	1510.77	27.65	19.50	8.36	8.86	2.24	9.94
P_2 : 25 kg P_2O_5 ha^{-1}	965.15	1557.00	30.67	21.62	9.27	9.91	2.50	11.08
P_3 : 37.5 kg P_2O_5 ha^{-1}	967.75	1653.53	30.75	21.68	9.29	10.17	2.58	11.29
S.Em.±	26.62	37.82	0.85	0.60	0.26	0.36	0.09	0.39
C.D. at 5 %	79.09	112.38	2.51	1.77	0.76	1.08	0.28	1.16
Biofertilizers inoculation								
B_0 : No inoculation	901.69	1527.01	28.65	20.20	8.66	9.28	2.34	10.37
B_1 : Inoculation with *Azotobacter* and *PSB*	967.14	1620.52	30.73	21.66	9.29	10.02	2.54	11.17
S.Em.±	21.74	30.88	0.69	0.49	0.27	0.30	0.08	0.32
C.D. at 5 %	64.58	91.76	2.05	1.45	NS	NS	NS	NS
Interaction								
N x P x B	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	12.09	10.20	12.09	12.09	12.09	15.97	16.41	15.41

The biofertilizers (*Azotobacter + PSB*) inoculation to sesame seeds was brought significant variation in seed and haulm yields of sesamum (Table 4.8). Significantly the highest seed (967.14 kg ha^{-1}) and haulm (1620.52 kg ha^{-1}) yields of sesame were recorded with biofertilizers (*Azotobacter + PSB*) inoculation to sesame seeds. While the lowest seed (901.69 kg ha^{-1}) and haulm (1527.01 kg ha^{-1}) yields were recorded with no inoculation of biofertilizers. Similar results were found by Ghosh and Mohiuddin (2000) [5].

Nitrogen, phosphorus and potassium content in seed and haulm table 1 was significantly not influenced due to different levels of biofertilizers. The results given in table 2 exhibited that significantly the highest nitrogen and phosphorus (30.73 and 21.66 kg ha^{-1}) uptake by seed was obtained due to inoculation of biofertilizers (*Azotobacter + PSB*) to sesame seeds. The lowest nitrogen and phosphorus (28.65 and 20.20 kg ha^{-1}) uptake by seed was recorded in no inoculation of biofertilizers to sesame seeds. The nitrogen and phosphorus uptake by haulm was significantly not influenced due to different levels of biofertilizers. The potassium uptake by seed and haulm was significantly not influenced due to different levels of biofertilizers.

From this research work, it can be concluded that for getting maximum sesame seed and haulm yields should be nourished with N_3: 75 kg/ha, P_3: 37.5 kg/ha and B_1: Inoculation with azotobacter and PSB which was at par with N_2: 50 kg/ha and P_2: 25 kg/ha. Nutrient uptake (N, P and K) by seed and haulm was significantly higher the application of N_3: 75 kg/ha and P_3: 37.5 kg/ha which was at par with N_2: 50 kg/ha and P_2: 25 kg/ha. Nutrient uptake (N and P) by seed was significantly highest the B_1: Inoculation with azotobacter and PSB, While, the K uptake by seed was non-significant. Nutrient uptake (N, P and K) by haulm was non-significant to B_0: No inoculation and B_1: Inoculation with azotobacter and phosphate solubilizing bacteria.

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