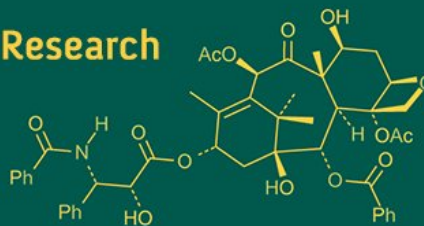


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Study of effect of the different levels of nitrogen, phosphorous and zinc sulphate use on yield and quality of summer sesame

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Abstract

A field experiment was conducted to evaluate the effect of varying levels of nitrogen (N), phosphorus (P), and zinc sulphate (ZnSO₄) on the yield and quality of summer sesame (*Sesamum indicum* L.). Different treatment combinations were applied to assess their influence on seed yield, oil content, and other agronomic parameters. Results indicated that balanced application of N, P, and Zn significantly enhanced plant growth, number of capsules per plant, seed weight, and overall grain yield. Additionally, optimal nutrient management improved oil content and quality traits, demonstrating the synergistic effect of macronutrients and micronutrients on sesame productivity. The findings suggest that integrated nutrient management with precise levels of N, P, and ZnSO₄ can be an effective strategy to maximize sesame yield and enhance oil quality, contributing to sustainable production under summer conditions.

Keywords: Nitrogen, Phosphorus, Zinc sulphate, Sesame, Yield, Oil content, Nutrient management, Summer cropping

Introduction

Oilseed crop include large variety of plants which are cultivated primarily for production of oil. Besides providing oil, they are also good source of fat and form highly nutritious human food. Sesame [*Sesamum indicum* Linn (Pedaliaceae)] is known by virtue of excellent quantity of oil and its use in domestic purpose. It is one of the most important edible crops grown next to groundnut & rapeseed-mustard. Besides providing oil, they are also good source of fat and form highly nutritious human food. Sesame is presumed to have originated in Africa and latter spread to West Asia to India, China and Japan.

In India sesame seeds are used for oil extraction (78%) edible purpose (20%) and seed purpose (2%) out of that 70% sesame seeds are used for edible purpose such as salad and cooking oil and remaining 30% for toilet soap and manufacture margarine (Rathore 2005). Sesame is known as benniseed, gingelly, sesame, sisim, til and hawari. The sesame seeds are rich source of food and edible oil, nutritious, healthcare and biomedicine. Its oil content generally varies from 48 to 52% and contain 6355 Kcal/kg energy in seeds (Kumar and Goel in 1994) [16] the seeds are also rich source of proteins (20%-28%), sugars (14-16%), minerals (5-7%) and nutrients like calcium (1.31%) and phosphorous (0.07%) (Dinosa and Gupta 1993) [9]. A sesame is regarded fatty acid component / composition of its oil and its resistance to oxidation and rancidity even when stores at ambient air temp. Due to the presence of potent antioxidant sesame seeds are called as "The Seeds of Immortality" with growing health consciousness and sesame has recently emerged as a valuable crop. Sesame is cultivated over an area of more than 7 million ha in world with an annual production of 4 million tones and yield of 535 kg ha⁻¹, India, Myanmar, Sudan, China are the major sesame growing countries. (Anonymous, 2014).

It is noteworthy that is recent sesame seeds have been found to contain immunoglobulin E (IgE)-mediated food allergens, with research report from France (Agne *et al.*, 2003) [1], Israel (Dalal *et al.*, 2002) [5], Italy (Pastorello *et al.*, 2001) [22] and the U.S. The more prevalence of sesame seed allergy is probably attributed to the wider and expanding use of sesame seed in baked products and fast foods. Moreover, farmers in most of the time do not go for cultivation during summer season with scanty irrigation water and also for the fear of crop

fosses. Hence, summer sesame becomes necessary to be an alternative oil seed crop which can be fit for fairly hot conditions during summer and can be produced with limited irrigation requirement to obtain maximum yield which ultimately uplift the economy of the farmers during the season. With this view a field trial was undertaken to study the “effect of the different levels of nitrogen, phosphorous and zinc-sulphate use on yield and quality of summer sesame.”

Materials and Methods

A field experiment entitled “Response of summer sesame (*Sesamum indicum* L.) to the levels of nitrogen, phosphorus and zinc sulphate under irrigated condition” was conducted in summer season during the year 2017, at Department of Agronomy Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.).

Soil

To determine the physico-chemical properties of soil, samples from surface 0-30 cm depth were drawn before laying out the experiment from randomly selected spots from the entire experimental area. The soil under the very experimental area was analyzed which was low in available nitrogen (N) medium in available phosphorus (P), and high in available potassium (K).

Climate and weather

Akola is situated in the subtropical region at 22.42° N latitude and of 77.02° E longitude and at an altitude of 307.4 meters above mean sea level. The climate of the area is semi-arid characterized by three distinct season viz., hot and dry summer from March to May, warm and rainy monsoon from June to October and mild cold winter from November to February.

Experimental details

Treatments

The experiment was carried out with 9 treatment combinations replicated 3 times. The allotment of the treatments to various plot were done randomly.

Treatment details:

T₁ - CONTROL

T₂ - 100% RDF

T₃ - 125% RDF

T₄ - 100% RDF + 10 Kg ZnSO₄

T₅ - 125% RDF + 10 Kg ZnSO₄

T₆ - 100% RDF + 20Kg ZnSO₄

T₇ - 125% RDF + 20 Kg ZnSO₄

T₈ - 100% RDF + 30 Kg ZnSO₄

T₉ - 125% RDF + 30 Kg ZnSO₄

Various field operations carried out for the experiment undertaken for summer sesame crop during the crop season

Sampling technique of Yield attributes and Yield

Number of capsules plant⁻¹ and No. of flowers plant⁻¹

The number of capsules and number of flowers from five selected observational plants was counted and means were calculated to obtain average number of capsules plant⁻¹ and number of flowers respectively.

Capsule weight per plant (g)

After counting the number of capsules plant⁻¹, the capsules from each of five plants were cut and air-dried separately

followed by hot air oven drying. The weight of capsule plant⁻¹ was then worked out.

Grain weight plant⁻¹(g)

The grains from five observational plants were weighed separately and average grain weight was then worked out.

Seed weight capsule⁻¹(g)

The seed from single capsule of every observational plant from plots were weighed separately and mean were calculated to obtain average weight of seeds capsule⁻¹.

Test weight (g)

Thousand seeds were counted and then weighed which were taken from a composite sample of seeds from produce of each net plot as measured in g.

Grain yield (kg ha⁻¹)

The produce of net plot was collected, threshed cleaned and weighed separately for both seed and straw. The yield of observational plant was added to the net plot yield. Yield plot⁻¹ was weighed and expressed as kg plot⁻¹ and it was calculated in to hectare⁻¹ then calculated for each treatment and expressed as seed yield kg ha⁻¹.

Straw yield (kg ha⁻¹)

The weight of the straw was recorded for each treatment. This was done by deducting the weight of grain from the total weight of plants harvested and the weight was expressed as straw yield kg ha⁻¹.

Harvest index (%)

Harvest index was calculated by using the following formula,

$$\text{H.I. (\%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

Quality study

Oil content (%)

The oil percentage in seed was estimated separately as per the treatment by Nuclear Magnetic Resonance (NMR) spectrophotometer against a standard reference sample according to A.O.A.C. (1975).

Oil yield ha⁻¹

From oil percentage seed oil yield was worked out by using following formula,

$$\text{Oil yield kg ha}^{-1} = \frac{\text{Seed yield} \times \text{Oil content (\%)}}{100}$$

Statistical analysis and interpretation of data

The experimental data collected during the course of investigation were statistically analyzed with randomized block design (RBD) programmed by adopting standard statistical techniques of analysis of variance (Gomez and Gomez, 1984) [13].

Results and Discussion:

Yield attributes and yield studies

Number of capsule plant⁻¹

Table 1 revealed that, number of capsule plant⁻¹ was affected significantly due to various treatments and mean

number of capsule plant⁻¹ was 67.95.

Table 1: Effect of different treatments on number of capsules plant⁻¹

Treatment	50 DAS	70 DAS	90 DAS	At harvest
T ₁ - Control	8.13	45.28	60.03	60.03
T ₂ - 100% RDF	8.02	49.87	63.95	63.95
T ₃ - 125% RDF	9.68	51.50	67.91	67.91
T ₄ - 100% RDF + 10 kg ZnSo ₄	9.92	55.40	66.63	66.63
T ₅ - 125% RDF + 10 kg ZnSo ₄	10.73	55.10	69.57	69.57
T ₆ - 100% RDF + 20 kg ZnSo ₄	11.08	58.47	70.36	70.36
T ₇ - 125% RDF + 20 kg ZnSo ₄	10.40	59.73	71.40	71.40
T ₈ - 100% RDF + 30 kg ZnSo ₄	10.77	57.17	70.10	70.10
T ₉ - 125% RDF + 30 kg ZnSo ₄	11.50	61.77	71.57	71.57
SE(m) ±	0.28	0.60	0.72	0.72
CD @ 5%	0.83	1.80	2.17	2.17
General mean	10.03	54.92	67.95	67.95

Effect of nitrogen and phosphorus

Levels of nitrogen significantly influenced the number of capsule plant⁻¹. 125% N along with 30 kg ZnSo₄ recorded the highest number of capsule plant⁻¹ (71.57), which was found significantly superior over all the treatments and control (60.03) and P2O₅ levels. In T₃ (125% RDF) recorded more significance over T₂ and T₁ (control), where as T₉ is on par with T₆, T₅, T₇ and T₈ but found significantly superior to rest over treatments respectively. It might be due to more availability of nitrogen during crop growth and increase in nutrient uptake in the root zone with adequate water supply and favourable temperature and adequate moisture during their growth period resulting in better growth and beneficial effect on flowering respectively. These findings are in line with M. Asghar Malik *et al.* (2001) [17] and H. K. Patel *et al.* (2011) [23], and with A. K. Pagal *et al.* (2015-16) and Tulasi Laxmi Thentu *et al.* (2011-12) [38].

Effect of Zinc sulphate

Effect of zinc sulphate on number of capsules plant⁻¹ was found significant. Among the different doses of ZnSo₄ 30 kg ZnSo₄+ 125% RDF recorded superiority over other treatments and at par with 20 kg and 30 kg ZnSo₄ combining with 100% and 125% RDF simultaneously in T₆, T₇, T₈ treatments. This might be because of sulphur helps in chlorophyll synthesis and improve seed production. Whereas zinc is the part of enzyme system and which regulate plant growth and yield contributing characters. These results are found similar with S. H. Shehu (2005-06) and Suchhanada Mondal (2012).

Capsule weight plant⁻¹ (g)

The weight of capsule plant⁻¹ was given in Table 2, indicating that capsule weight plant⁻¹ was significantly

influenced due to various treatments. The mean weight of capsule plant⁻¹ was 18.46 g.

Effect of nitrogen and phosphorus

Nitrogen significantly influenced the weight of capsule plant⁻¹. Nitrogen recorded highest weight of capsule plant⁻¹ in T₉ (21.07 g), which was found significantly superior over all the treatments and at par with T₆ (21.00). The increase in yield attributes might be due to more uptake of nitrogen during the period of growth and availability of water at reproductive phase when plants need more moisture. As well as it might be due to favourable temperature during their growth period resulting in better growth and beneficial effect on flowering, better capsule setting and seed filling. These results are found in agreement with R. R. Damdar *et al.* (2011) and Kalpana Jamdhade *et al.* (2011) [14]. And Vinod A. Khadse *et al.* (2011-12) and H. K. Patel *et al.* (2011) [23].

Effect of zinc sulphate

Effect of zinc sulphate reached to the level of significance. Along with 100% and 125% RDF 20 kg and 30 kg ZnSo₄ [4] in T₆ and T₉ respectively produced good results than rest others and shows significance over them, on par with each other. Results found in line with Gayatri Sahu *et al.* (2015) and Puste A. M. *et al.* (2015) [25].

Seed weight plant⁻¹ (g)

Effect of nitrogen

Nitrogen with 125% RDF significantly influenced the weight of seed plant⁻¹. In T₃ (125% RDF i.e. 31.25 kg N) recorded highest weight of seed plant⁻¹ (11.99 g), which was found significantly superior over control (8.45 g) and at par with T₂ (100% RDF).

Table 2: Mean capsule weight plant⁻¹ (g), seed weight plant⁻¹ (g), Number of seeds capsule⁻¹ and test weight (g) (1000 seed weight) as influenced by various treatments

Treatments	Capsule wt. plant ⁻¹	Seed wt. plant ⁻¹	Seeds capsule ⁻¹	Test weight
T ₁ - Control	13.09	8.45	61.00	3.49
T ₂ - 100% RDF	16.90	11.58	59.67	3.85
T ₃ - 125% RDF	18.38	11.99	61.67	3.71
T ₄ - 100% RDF + 10 kg ZnSo ₄	19.50	12.26	62.00	3.88
T ₅ - 125% RDF + 10 kg ZnSo ₄	18.48	12.64	64.00	3.62
T ₆ - 100% RDF + 20 kg ZnSo ₄	21.00	15.33	64.67	3.98
T ₇ - 125% RDF + 20 kg ZnSo ₄	18.38	13.60	61.67	3.68
T ₈ - 100% RDF + 30 kg ZnSo ₄	19.38	13.52	63.00	3.63
T ₉ - 125% RDF + 30 kg ZnSo ₄	21.07	15.76	63.00	4.09
SE(m) ±	0.67	0.39	0.98	0.07
General mean	18.46	12.79	62.30	3.77
CD @ 5%	1.11	1.16	NS	0.23

125% RDF in which 31.25 kg N was given with ZnSO_4 levels or not produce good results than 100% RDF. Increase in this yield component is mainly attributed to better performance of plants with respect to growth parameters like plant height, number of leaves, LAI and total dry matter production. This is mainly due to the optimum uptake of nitrogen during the growth by the roots which favours plant growth throughout growing period reflecting better growth attributes. These results are found in agreement with R. R. Damdar *et al.* (2011) and Kalpana Jamdhade *et al.* (2011) [14].

Effect of phosphorus and zinc sulphate

Phosphorus and zinc sulphate levels significantly influenced the seed weight plant⁻¹. 125% RDF with 30 kg ZnSO_4 , recorded the highest seed weight plant⁻¹ (15.76 g), which was found significantly superior over all the treatments but at par with T_6 (100% RDF+ 20 kg ZnSO_4). In T_5 (125% RDF+ 10 kg ZnSO_4) was also found significantly superior over T_3 , T_2 and on par with T_4 . It is likely that water stress at seed setting stage resulted in avoided by providing ample amount of water at capsule and development stages resulting in the more accumulation of P_2O_5 and other nutrients ultimately in the grains which helps to increase seed weight per plant. These results are similar with Vinod A. Khadse *et al.* (2011-12) and H. K. Patel *et al.* (2011) [23] and with Gayatri Sahu *et al.* (2015) and Puste A. M. *et al.* (2015) [25] respectively.

Test weight (g): Test weight was presented in Table 2, indicating that test was significantly influenced due to various treatments. The mean test weight was 3.77 g.

Effect of nitrogen, phosphorus and zinc sulphate

Nitrogen, phosphorus and zinc sulphate application

significantly influenced test weight. Nitrogen, phosphorus and zinc sulphate levels with 125% RDF+ 30 kg ZnSO_4 (T_9) recorded the highest test weight (4.09 g), which was found significantly superior over all the treatments and on par with 100% RDF+20 kg ZnSO_4 (T_6). It might be due to efficient seed filling by better translocation of photosynthates by application of higher nitrogen doses resulted in improved weight of 1000 seeds. Due to phosphorus allows more photosynthates translocation towards seed after maturity, and due to Zinc accumulation at maturity stages when plant attains its full growth takes place in seeds thus sesame seeds are efficient source of zinc respectively. These results are in agreement with H. K. Patel *et al.* (2011) [23] and S. Tripathi *et al.* (2010-11), found ilar with Ashwani Kumar Thakur *et al.* (2012-13) A. Chakraborty (2009-10) [4], and Jaishankar S. *et al.* (2004) and Deshmukh S. S. *et al.* (2010).

Seeds capsule⁻¹

Seeds per capsule is furnished in the table 2. The mean numbers of seeds found per capsule are (62.30).

Effect of nitrogen, phosphorus and zinc sulphate

Effect of levels of nitrogen and phosphorus on number of seeds per capsule is found non-significant as seen in the table 2. Similar results were found in the study of M. Asghar Malik *et al.* (2001) [17] and Z. Nahar *et al.* (2002), S. Tripathi *et al.* (2010-11) and Amanullah Jan. *et al.* (2013) [2] and Mean number of seeds capsule⁻¹ were also not significantly influenced by application of ZnSO_4 at different rates. Results are found similar with H. E. Shehu (2005-06).

Seed yield (q ha⁻¹)

The average seed yield of summer sesame was 956.85 kg ha⁻¹.

Table 3: Mean seed yield (kg ha⁻¹), straw yield (kg ha⁻¹), and harvest index (%) as influenced by various treatments

Treatments	Seed yield (kg ha ⁻¹)	Straw yield (kg ha ⁻¹)	Harvest index %
T_1 - Control	563	3449	14.04
T_2 - 100% RDF	821	4606	15.12
T_3 - 125% RDF	847	4777	15.07
T_4 - 100% RDF + 10 kg ZnSO_4	943	5055	15.72
T_5 - 125% RDF + 10 kg ZnSO_4	957	5261	15.39
T_6 - 100% RDF + 20 kg ZnSO_4	1116	5614	16.58
T_7 - 125% RDF + 20 kg ZnSO_4	1079	5540	16.30
T_8 - 100% RDF + 30 kg ZnSO_4	1135	5596	16.86
T_9 - 125% RDF + 30 kg ZnSO_4	1151	5671	16.87
SE(m) $\pm$	12.30	41.25	0.21
CD @ 5%	36.87	123.68	0.64
General mean	956.85	5063.19	15.77

Effect of nitrogen and phosphorus

Nitrogen had significantly influenced the seed yield. 125% RDF (T_3) has significant results recorded the highest seed yield than control (T_1) but on par with 100% (T_2) having value of (T_3) is 847 kg ha⁻¹. The highest seed yield obtained is 1151 kg ha⁻¹ in (T_9) which is best over all the treatments and quiet at par with 1116 kg ha⁻¹ (T_6) and 1135 kg ha⁻¹ (T_8). Increased supply of nitrogen resulted in greater cell elongation and increased leaf area leads to increased dry matter, number of capsules which resulted in higher yield as well as it might be due to optimum plant development with adequate moisture level resulted in better translocation of photosynthates and accumulation of food to the site of capsule formation. Thus it increases the plant growth which

ultimately provides a large frame on which more flowers and eventually more capsule per plant developed. These results are found nearly similar with O. M. Kasab *et al.* (2000-01), R. K. Sarkar *et al.* (2001-02) [26] and A. Chakraborty (2009-10), A. K. Pagal *et al.* (2015-16) S. Tripathi *et al.* (2010-11), Deshmukh *et al.* (2010) [8] and A. Chakraborty (2009-10).

Effect of zinc sulphate

An effect showed seed yield ha⁻¹ had significant differences amongst all the treatment combinations of zinc sulphate doses with RDF and increased RDF. In these combinations 100% RDF+30 kg ZnSO_4 (T_9), 100% RDF+ 30 kg ZnSO_4 (T_8) and 100% RDF+ 20 kg ZnSO_4 (T_6) with values (1151

kg ha⁻¹), (1135 kg ha⁻¹) and (1116 kg ha⁻¹) respectively superior over 100% & 125% RDF with 10 kg ZnSO₄ in T₄ & T₅ and 125% RDF with 20 Kg ZnSO₄ (T₇). Both zinc and sulphur aids in seed formation. As they found effective constituent of chlorophyll synthesis and increased rate of photosynthesis by exploiting vigorous plant growth and photosynthates translocation towards yield attributing characters. These results are found similar with H. E. Shehu (2005-06) and Puste A. M. *et al.* (2015) [25] with sulphur levels.

Straw yield (q ha⁻¹)

The average straw yield of summer sesame was 5063.19 kg ha⁻¹.

Effect of nitrogen and phosphorus on Straw yield (q ha⁻¹)

Nitrogen and phosphorus affected stalk yield of sesame significantly with multiple numbers of irrigations. Highest straw yield (5671 kg ha⁻¹) was obtained by application of 125% RDF + 30 kg ZnSO₄, which was significantly superior rest others but at par with T₆, T₇, and T₈. Also only with 125% RDF *i.e.* 31.25 kg N produce significant results over 100% RDF and control. This might be due to improvement of growth parameters by increase in N and P doses with adequate irrigation water during different growth stages resulted in higher biomass production and caused maximum stalk and straw yield. These results are in conformity with A. Chakraborty (2009-10) [4], Sonia Shilpi *et al.* (2009) [34] and Zeinolabedin Jooyban *et al.* (2009), Shahzad Ali *et al.* (2012) [28] and A. K. Pagal *et al.* (2015-16).

Effect of zinc-sulphate

Zinc-sulphate produce most superior results with RDF combinations than only RDF and Increased rate of RDF. 125% RDF+ 30 kg ZnSO₄ (T₉), 100% RDF+ 30 kg ZnSO₄ (T₈) and 100% RDF+ 20 kg ZnSO₄ (T₆) with higher straw and stalk yield values 5671 kg ha⁻¹, 5596 kg ha⁻¹ and 5614 kg ha⁻¹ respectively shown superiority over other ZnSO₄ and RDF combinations. Sulphur is known for master nutrient for oilseeds production where as zinc is emerging as one of the crucial micro-nutrient for the vigorous vegetative growth and more dry matter accumulation as same observed here. Also adequate soil moisture balance maintained during all the stages flourished vegetative growth in compliment with ZnSO₄. Similar results were found with application Zn and sulphur N. N. Parmar *et al.* (2015-16), Sonia Shilpi *et al.* (2009) [34] and S. H. Shehu (2005-06).

Harvest index (%)

Effect of nitrogen and phosphorus

The highest harvest index (18.87 %) was observed in T₉ than RDF and RDF+ZnSO₄ combinations. The minimum harvest index found was in T₁ *i.e.* control and value is 14.04%. Similar results found in S. tripathy *et al.* (2010-11) and Amanullah Jan. *et al.* (2013) [2].

Effect of zinc sulphate

As far as different ZnSO₄ levels are concerned highest harvest index was observed in T₉ *i.e.* 125% RDF+ 30 kg ZnSO₄ (18.87%) and lowest with T₄ *i.e.* 100% RDF+10 kg ZnSO₄ and value is 15.72%. Similar results are found by A. K. Pagal. *et al.* (2015-16), Muhammad Asghar Shah *et al.* (2008) and Sanaullah *et al.* (2011) in sunflower with ZnSO₄

application.

Quality study

Oil content (%)

Effect of nitrogen and phosphorus on oil %

Effect of nitrogen on oil content was though found significant but level of significance is not that so great extent but least only. 31.25 kg N show significance only over control and at par with 25 kg N. These are found in agreement with the results of Fathy S. *et al.* (2007) [11], Snehangshu Sekhar Nayak *et al.* (2009-10) [32], M. Asghar Malik *et al.* (2001) [17] and H. K. Patel *et al.* (2011) [23], and Oil content was affected significantly due to different phosphorus levels same as influenced by nitrogen levels in the same treatments. Similar results were obtained by Shahzad Ali *et al.* (2011), P. S. De *et al.* (2010) and Tulasi Laxmi Thentu *et al.* (2011-12) [38].

Effect of zinc-sulphate on oil content %

Actually oil content was influenced to the extent of significance by levels of ZnSO₄ with 100% and 125% RDF than only RDF levels and control plots. The highest oil content observed is with T₆ (49.80) but at par with T₄, T₅, T₇, T₈ and T₉ and slightly differs. This might be due to increased levels of S and Zn through ZnSO₄. Results obtained are found similar with A. M. A. El-Sherif (2013-14), H. E. Shehu (2005-06), Fathy S. *et al.* (2007) [11] and Snehangshu Sekhar Nayek *et al.* (2009-10).

Table 4: Mean oil % and oil yield (kg ha⁻¹) as influenced by various treatments

Treatment	Oil %	Oil yield (kg ha ⁻¹)
T ₁ - Control	46.80	263.52
T ₂ - 100% RDF	48.54	398.31
T ₃ - 125% RDF	48.86	413.98
T ₄ - 100% RDF + 10 kg ZnSO ₄	49.01	462.29
T ₅ - 125% RDF + 10 kg ZnSO ₄	49.40	472.72
T ₆ - 100% RDF + 20 kg ZnSO ₄	49.80	555.57
T ₇ - 125% RDF + 20 kg ZnSO ₄	49.44	533.62
T ₈ - 100% RDF + 30 kg ZnSO ₄	49.61	563.04
T ₉ - 125% RDF + 30 kg ZnSO ₄	49.45	569.13
SE(m) ±	0.26	7.78
CD @ 5%	0.78	23.33
General mean	48.99	470.24

Oil yield (q ha⁻¹)

The data regarding oil yield as influenced by various treatments are presented in Table 4 and graphically depicted in Fig.1

Effect of nitrogen and phosphorus on oil yield

Effect of nitrogen and phosphorus on oil yield was found to be significant. If considered nitrogen and phosphorus levels 125% RDF in T₃ treatment recorded oil yield of 413.98 kg ha⁻¹ which was significantly superior over control T₁ (263.52 kg ha⁻¹) and T₂ (398.31 kg ha⁻¹) similarly. Oil yield is a function of oil content and seed yield thus, increased significantly with different nitrogen levels. These are found in agreement with the results of Fathy S. *et al.* (2007) [11], Snehangshu Sekhar Nayak *et al.* (2009-10) [32], M. Asghar Malik *et al.* (2001) [17] and H. K. Patel *et al.* (2011) [23]. And Shahzad Ali *et al.* (2011), P. S. De *et al.* (2010) and Tulasi Laxmi Thentu *et al.* (2011-12) [38].

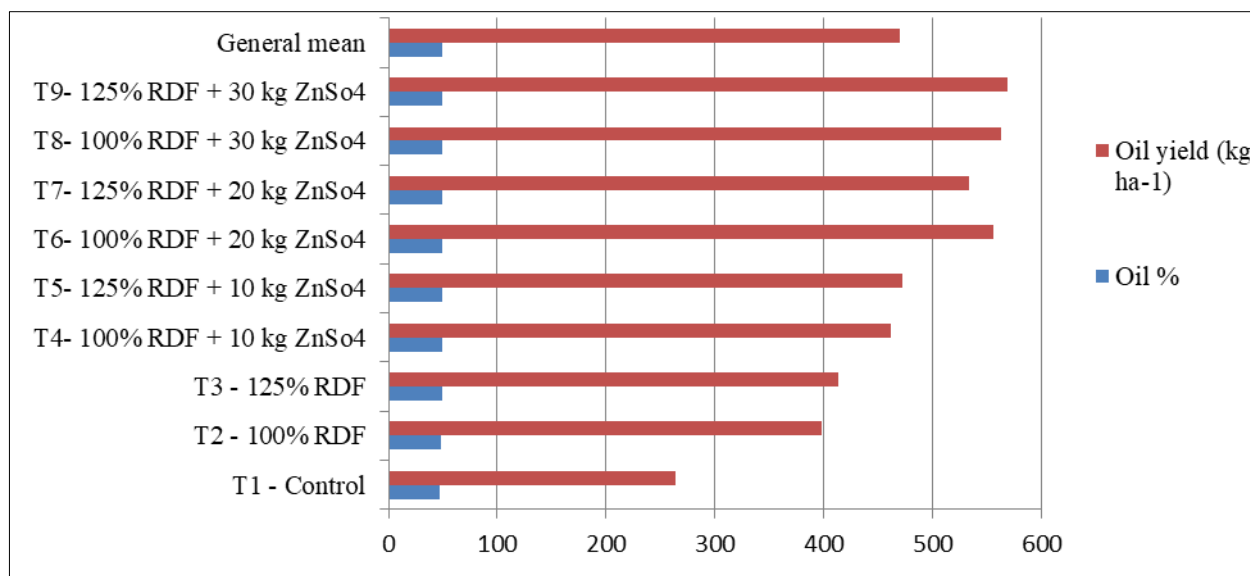


Fig 1: Effect of nitrogen, phosphorus and Zinc-sulphate on oil yield and Oil %

Effect of zinc sulphate on oil yield

The effect of zinc sulphate seen emphacitically on oil yield. Because higher ZnSo₄ doses with RDF combinations provide much better results in oil yield per hactor. Among the different levels of ZnSo₄ and RDF combinations T₉ (569.13 kg ha⁻¹), T₈ (563.04 kg ha⁻¹) and T₆ (555.57 kg ha⁻¹) produce maximum oil yield. This might be due to contribution of sulphur and zinc whose role comes into play at final time and cause increase in oil yield. Results obtained are found similar with A. M. A. El-Sherif (2013-14), H. E. Shehu (2005-06), Fathy S. *et al.* (2007) and Snehangshu Sekhar Nayek *et al.* (2009-10).

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