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Effect of organic sources of nitrogen and panchagavya on yield and quality of sesame (*Sesamum indicum* L.)

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Abstract
A field experiment was conducted to study the effect of organic sources of nitrogen and panchagavya on yield and quality of sesame during *kharif* seasons of 2023. The experiment was laid out in Factorial Randomized Block Design with five organic source of nitrogen *viz*, Control, 100% RDN through FYM, 100% RDN through FYM + *Azospirillum* and PSB, 80% RDN through FYM + *Azospirillum* and PSB and 60% RDN through FYM + *Azospirillum* and PSB as first factor and four Panchagavya spray *viz*. Control, 3% spray of panchagavya at 30 DAS, 3% spray of panchagavya at 45 DAS and 3% spray of panchagavya at 30 DAS + 45 DAS as second factor. The results reported that the higher yield attributes and yield *viz*. number of capsules plant^{-1}, seeds capsule^{-1}, test weight, seed yield, stalk yield, biological yield as well as protein and oil content in seed were recorded under 80% RDN through FYM + *Azospirillum* and PSB. However it was statistically at par with 100% RDN through FYM + *Azospirillum* and PSB during experimentation. Among the foliar application of panchagavya, 3% panchagavya at 30 + 45 DAS recorded higher values of number of capsules plant^{-1}, seeds capsule^{-1}, test weight, seed yield, stalk yield, biological yield as well as protein and oil content in seed.

Keywords: Sesame, biofertilizers, panchagavya, *Azospirillum* and biologicakl yield

Introduction
The ancient oilseed crop known as sesame (*Sesamum indicum* L.) was domesticated around 3,000 years ago. Sesame belongs to the family Pedaliaceae, commonly known as "til" gingely, simsim, gergelim and biniseed, also called as "Queen of oilseeds". During the Past two decades, there has been a surge in the demand for sesame seeds owing to their superior oil quality, protein richness, antioxidant properties and remarkable adaptability to diverse climatic and soil conditions (Myint *et al.*, 2020) [12]. It is also popular as a cooking oil in south India and the sesame oil cake is used as feed for the dairy animals as well as manure which contains 6.0 to 6.2% nitrogen, 2.0 to 2.2% phosphorus and 1.0 to 1.2% potash. Its seeds are extremely nutrient-dense and palatable, and its oil content typically ranges from 46% to 52%, making it extremely resistant to oxidative rancidity (Iwo *et al*., 2002) [9]. Sesame oil is also referred to as "poor man's substitute for ghee". In addition to proteins and carbs, oil is a crucial component of the human diet (Kalegore *et al*., 2018) [10]. They have a protein level of 18-25%, a carbohydrate content of 13.5%, and an ash content of 5%. They also have nutritional and therapeutic advantages. Consuming sesame seeds seems to boost vitamin E activity and plasma gamma-tocopherol, which are thought to protect heart disease and cancer (Cooney *et al.*, 2001) [6]. Sesame meal-based products are considered appropriate for individuals with diabetes due to their lower carbohydrate content and higher protein content (Bigoniya *et al.*, 2012) [4].

Nitrogen is the primary macronutrient needed for plant growth and development out of all the basic nutrients. Nitrogen is the integral part of amino acids, nucleic acids, chlorophyll, proteins and an important component of energy molecule *i.e,* ATP and ADP. Since soil microflora negotiates all nutrient processing, excessive use of chemical fertilisers degrades the biological power of the soil, which must be avoided. The soil microflora gets its energy from organic materials. Potential micronutrient sources include organic manures, which also enhance soil structure by binding soil aggregates and improving soil water retention, nutrient use efficiency, and buffering capacity. In order to maximize agriculture production and soil health, use of organic manure *i.e.*, FYM as a part of nutrient management strategy help in mitigating the multiple nutrient deficiencies. Application of farm yard manure (FYM) improves soil physical, chemical, and biological properties (Ahmed *et al*., 2010) [3]. FYM gives the soil a black hue, which helps to keep the soil at a consistent temperature. Due to its early availability and inclusion of nearly all the nutrients needed by plants, FYM is one of the oldest manures used by farmers to cultivate crops (Das *et al*., 2008) [7]. On the other hand, biofertilizers are applied in the agricultural field as a supplement to our conventional fertilizers because the chemical fertilizers are not environment friendly. Biofertilizers contain living microorganisms which promote the adequate supply of nutrients to the plants to ensure their proper development, growth and regulation in their physiology. In common, microbes commonly utilized as biofertilizers might be *Azotobacter*, *Azospirillum* and *Rhizobium* as nitrogen-fixing soil bacteria. PSB provides alternative solution in sustainable agriculture to meet the phosphorus demand of the plant. Panchagavya acts as a growth promoter (75%) and immunity booster (25%) and exactly fills the missing ink to sustain organic farming without any yield loss (Vedivel, 2007) [20]. Panchagavya are cheaper eco-friendly organic product made by cow products namely dung, urine, milk, curd and ghee (Gore and Sreenivasa, 2011) [8].

However, information regarding organic nitrogen sources in sesame production in Rajasthan is lacking. Keeping in view the above discussed facts of sufficient information and sparce related research, the present investigation was undertaken to find out the effect of Organic Sources of Nitrogen and Panchagavya on Yield and Quality of Sesame in Jaipur conditions.

Materials and Methods

The experiment was conducted during *kharif* seasons, 2023 at the Agronomy farm, S.K.N. College of Agriculture, Jobner, Jaipur, situated at latitude of 26°05′ North and longitude of 75°28′ East, with altitude of 427 meters above the mean sea level. The total rainfall of 403.4 mm was received during crop growing season. Soil of the experiment field had loamy sand in texture, slightly alkaline in reaction, medium in electrical conductivity, low in organic carbon, available nitrogen and medium in available phosphorus and potassium.

The experiment was laid out in Factorial Randomized Block Design with five organic source of nitrogen *viz*, Control, 100% RDN through FYM, 100% RDN through FYM + *Azospirillum* and PSB, 80% RDN through FYM + *Azospirillum* and PSB and 60% RDN through FYM + *Azospirillum* and PSB as first factor and four Panchagavya spray *viz*. Control, 3% spray of panchagavya at 30 DAS, 3% spray of panchagavya at 45 DAS and 3% spray of panchagavya at 30 DAS + 45 DAS as second factor. The treatments were replicated three times. Each plot was surrounded by a buffer of 1.0 m width to protect the plots from accidental irrigation and gain of water through seepage. The recommended dose of nitrogen (20 kg ha^{-1}) were applied through FYM having nutrient contents of 0.5% N, 0.25% P_2O_5 and 0.5% K_2O was applied in the field as per treatments and was thoroughly mixed two week before sowing of sesame. While biofertilizers @ 600 g ha^{-1} was mixed with jaggery solution which was prepared by boiling the jaggery in water and the seeds required for one hectare are mixed in the slurry so as to have uniform coating of the inoculants over the seeds and then dried in shade for 30 minutes. Seed treatment with biofertilizers was done by taking the culture of biofertilizer @ 5 ml of formulation and dissolved in sufficient quantity of water to treat one kg seed. The seeds are well coated with the solution and dried under the shade before sowing. However, panchgavya were applied as per treatment as foliar mean. Sesame variety "RT-372" was used for sowing. Observations were recorded as per standard procedure. The data relating to each character were analyzed as per the procedure of analysis of variance and significance was tested by "F" test (Gomez and Gomez 1984) [1].

Results and Discussion

Organic sources of nitrogen and panchagavya influenced significantly all the yield attributing characters *viz*, number of capsules $plant^{-1}$, seeds $capsule^{-1}$ and test weight at harvest stage (Table 1). Application of 80% RDN through FYM + *Azospirillum* and PSB, being at par with 100% RDN through FYM + *Azospirillum* and PSB, registered significantly higher number of capsules $plant^{-1}$ (38.97), seeds $capsule^{-1}$ (44.98) and test weight (2.76 g) which was significantly higher over rest of the treatments. As mentioned in the paragraphs above, this can be attributed to general gains in crop growth and vitality. When FYM is added to soil, it encourages rapid vegetative growth and branching, which increases the sink size in terms of blooming, fruiting, and seed laying since it includes nearly all of the needed plant nutrients. The yield qualities may have grown as a result of the FYM application's enhanced general growth and profuse branching, as well as the photosynthetic transfer to reproductive structures. On the other hand, the increase in yield attributes due to seed inoculation with *Azospirillum* + *PSB* might be due to production of growth promoting substances such as auxins, gibberellins and cytokinin which might improve plant growth and stimulate the microbial development. This favourable effect of bacterial inoculation could be attributed to increased solubilization of mineral phosphates and other nutrients and also increase in nitrogen and phosphorus supply in inoculated plot due to nitrogen fixation and phosphorus solubilization ability of these bacteria and which is ultimately increased all the yield attributes of sesame. Ravusaheb *et al.* (2010) [15] reported that application of FYM + seed inoculation with *Azospirillum* provided highest number of capsules $plant^{-1}$ and number of seeds $capsules^{-1}$ of sesame. Kumar *et al.* (2018) [11] revealed that the significantly higher number of capsules $plant^{-1}$ and number of seeds $capsules^{-1}$ of sesame was recorded with the seed inoculation by Arbuscular Mycorrhizal Fungi + Azospirillum+ Phosphate Solubilizingn Bacteria.

Among the different treatments (Table 2), the maximum seed yield (650 kg ha^{-1}), stalk yield (1798 kg ha^{-1}) and biological yield (2448 kg ha^{-1}) of sesame was recorded with application of 80% RDN through FYM + *Azospirillum* and PSB which was significantly higher in comparison to rest of the treatments. Data further revealed that application of 80% RDN through FYM + *Azospirillum* and PSB remained statistically at par with 100% RDN through FYM + *Azospirillum* and PSB. While, harvest index was found to be non-significant. The notable improvement in dry matter production, growth characteristics, and yield attributes such as capsules $plant^{-1}$ and seeds $capsule^{-1}$, which ultimately led to increased seed yield, may indicate that FYM's beneficial influence on maintaining a balanced source-sink relationship is the cause of the notable increase in seed yield. By directly influencing the dry matter production of each vegetative part and indirectly through improved morphological parameters of development (plant height and number of branches), FYM + biofertilizers have been shown to boost stalk yield. Given that seed and stalk yield, which indicate the crop's vegetative and reproductive development, determine biological yield. FYM manuring had a significant impact on each of these crop growth components, which resulted in increased biological yield. Shaikh *et al.* (2010) reported that the significantly higher seed and stalk yields of sesame were recorded with application of RDF + 5 t FYM ha^{-1} + 5 t vermicompost ha^{-1} + seed treatment of *Azospirillum* and PSB over control. Similar findings were also suggested that significantly higher seed yield and stalk yield of sesame were recorded under treatment of 50% RDF + 5.0 t FYM ha^{-1} + *PSB* + *Azotobacter* (Parmar *et al.*, 2020) [13]. The results of the present investigation corroborate the findings of Sahu *et al.* (2017) [16], Samant (2020) [18], Aglawe *et al.* (2021) [2] and Salman *et al.* (2022) [17].

Among the different treatments (Table 3), the application of 80% RDN through FYM + *Azospirillum* and PSB recorded significantly higher protein content (22.08%) and oil content (45.85%) in sesame seed which proved significantly superior as compared to other treatments and remained at par with 100% RDN through FYM + *Azospirillum* and PSB. Higher cellular metabolic activity and higher nitrogen availability in the root zone may have led to a rise in nutrient absorption and accumulation in vegetative plant parts. Higher nutrient accumulation in vegetative plant parts due to better metabolism resulted in higher nutrient translocation to the crop's reproductive organs, which in turn raised the nitrogen content of seed and, eventually, its protein and oil content. Similar finding was also recorded by Parmar *et al.* (2020) [13].

Foliar spray of 3% panchagavya at 30 + 45 DAS recorded significantly higher number of capsules $plant^{-1}$ (39.63), seeds $capsule^{-1}$ (45.51) and test weight (2.81 g) which was superior to all other remaining treatments. The significantly maximum seed yield (642 kg ha^{-1}), stalk yield (1810 kg ha^{-1}) and biological yield (2452 kg ha^{-1}) of sesame was recorded with foliar spray of 3% panchagavya at 30 + 45 DAS which was found superior over control rest of the treatments. The simple transport of nutrients and growth stimulants to plants by foliar spraying of the ideal level of panchgavya may be the cause of the increase in yield qualities. There are several explanations for why the panchgavya spray has boosted sesame production. When foliar sprayed, growth hormones like IAA and GA, which are found in smaller amounts in panchgavya, may have stimulated the plant system, increasing the production of growth regulators in the cell system. These growth regulators' action in the plant system then boosted the required growth and development, resulting in increased yield. Increased yield qualities resulting from higher dry matter accumulation and chlorophyll content may be linked to the greatest gain in biological and seed yield with any foliar treatment. Watsh *et al.* (2023) [21] reported that foliar spray of panchagavya (3%) gave significantly higher number of capsules per plant, number of seeds per capsule, test weight, seed yield, stalk yield and biological yields of sesame over control.

The foliar spray of 3% panchagavya at 30 + 45 DAS recorded significantly highest protein content (22.02%) and oil content (46.23%) of sesame seed which was found superior over rest of the treatments. In comparison to applying panchgavya at either the branching or flowering stage alone, Choudhary *et al.* (2017) [5] found that applying panchgavya at both stages resulted in the highest levels of N, P, K, S, Zn, and Fe content, uptake in seed and straw, and protein content in black gram seed. Sanjutha *et al.* (2008) [19], Ravi Kumar *et al.* (2011) [14] and Choudhary *et al.* (2021) [5] also found similar findings in different crops.

Table 1: Effect of organic sources of nitrogen and panchagavya on yield attributes of sesame

Treatment	Yield attributes		
	Capsules $plants^{-1}$	Seeds $capsule^{-1}$	Test weight (g)
Organic sources of nitrogen			
Control	31.10	38.11	2.11
100% RDN through FYM	35.13	41.53	2.44
100% RDN through FYM + *Azospirillum* and PSB	39.73	45.44	2.82
80% RDN through FYM + *Azospirillum* and PSB	38.97	44.98	2.76
60% RDN through FYM + *Azospirillum* and PSB	35.67	41.76	2.47
S.Em+	0.98	1.00	0.07
CD (P=0.05)	2.79	2.86	0.20
Panchagavya spray			
Control	31.83	39.12	2.20
3% spray of panchagavya at 30 DAS	36.79	42.59	2.56
3% spray of panchagavya at 45 DAS	36.22	42.24	2.51
3% spray of panchagavya at 30 + 45 DAS	39.63	45.51	2.81
S.Em+	0.87	0.89	0.06
CD (P=0.05)	2.50	2.56	0.18
CV (%)	9.36	8.17	9.43

Table 2: Effect of organic sources of nitrogen and panchagavya on yields and harvest index of sesame

Treatment	Yield (kg ha^{-1})			Harvest index (%)
	Seed yield	Stalk yield	Biological yield	
Organic sources of nitrogen				
Control	503	1422	1925	26.16
100% RDN through FYM	564	1589	2154	26.19
100% RDN through FYM + *Azospirillum* and PSB	656	1825	2481	26.51
80% RDN through FYM + *Azospirillum* and PSB	650	1798	2448	26.59
60% RDN through FYM + *Azospirillum* and PSB	583	1636	2218	26.28
S.Em+	14	41	47	0.56
CD (P=0.05)	40	118	135	NS
Panchagavya spray				

Control	533	1494	2026	26.28
3% spray of panchagavya at 30 DAS	600	1676	2275	26.37
3% spray of panchagavya at 45 DAS	590	1637	2227	26.54
3% spray of panchagavya at 30 + 45 DAS	642	1810	2452	26.20
S.Em+	13	37	42	0.50
CD (P=0.05)	36	105	121	NS
CV (%)	8.26	8.62	7.29	7.36

Table 3: Effect of organic sources of nitrogen and panchagavya on protein content and oil content of sesame

Treatment	Protein content (%)	Oil content%)
Organic sources of nitrogen		
Control	19.90	41.93
100% RDN through FYM	21.01	43.88
100% RDN through FYM + *Azospirillum* and PSB	22.27	46.15
80% RDN through FYM + *Azospirillum* and PSB	22.08	45.85
60% RDN through FYM + *Azospirillum* and PSB	21.21	44.24
S.Em+	0.19	0.45
CD (P=0.05)	0.54	1.28
Panchagavya spray		
Control	20.55	42.77
3% spray of panchagavya at 30 DAS	21.37	44.56
3% spray of panchagavya at 45 DAS	21.24	44.08
3% spray of panchagavya at 30 + 45 DAS	22.02	46.23
S.Em+	0.17	0.40
CD (P=0.05)	0.48	1.14
CV (%)	3.07	3.48

Conclusion
From the above overall study, it is recommended that to obtain higher yield attributes, yield and qualitative characters of sesame should be grown by application of 80% RDN through FYM + Azospirillum and PSB alongwith 3% spray of panchagavya at 30 DAS + 45 DAS stage under ago-climatic conditions of Jaipur region of Rajasthan.

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