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ANALYSIS OF INTEGRATED NUTRIENT MANAGEMENT WITH SUNFLOWER + APIARY SYSTEMS APPROACH

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ABSTRACT

Two sets of field experiments were conducted during the June-August months at the experimental farm of Bharath Institute of Higher Education and Research, Selaiyur of Chingleput district under irrigated conditions to trace the effect of integrated nutrient management and to assess the yield performance of sunflower +apiary farming system. The experiment consists of two main treatments; i.e, Sunflower alone (M1) ,Sunflower with apiary (M2) and nine sub treatments i.e, Control (S1), 100%RDF (S2), 100%RDF + *Azospirillum* (S3), 100% RDF +*Phosphobacteria* (S4), 100% RDF + Vermicompost (S5), 100%RDF+ *Azospirillum* + *Phosphobacteria* (S6), 100%RDF+ Vermicompost+ *Azospirillum* (S7), 100% RDF+ Vermicompost+ *Phosphobacteria* (S8), 100%RDF+ Vermicompost+ *Azospirillum*+ *Phosphobacteria*(S9) and it was laid out in split plot design with three replications .Highest performance for plant height, dry matter production, seeds/head, seed filling percentage, and seed yield were observed for the combined application of all three nutrient sources under sunflower + apiary (M2) treatment by bee pollination. A sunflower crop combined with an apiary, however, had a more noticeable impact than a sunflower crop alone. In addition to the available natural feeding sources, the apiary should be given superior feeding for a longer period of time. Two times every week, 500ml of sugar syrup is provided as food. The development of apiaries in sunflower fields would bring additional compensation and guarantee the growers' ability to support themselves . Value of growing energy costs and restricted input availability and further the transition towards natural farming have led to an increase in the use of integrated nutrient management, which recycles organic waste and uses renewable sources of bio fertilizers. This study looked into how organic manures, inorganic fertilizers, and bio fertilizers (INM) affected sunflower growth and productivity as influenced in combination with apiary integration.

Keywords : sunflower, nutrient management, bio fertilizers, apiary , farming system, dry matter production, seed filling percentage, seed yield.

Introduction:

Sunflower (*Helianthus annuus*(L.)), a last introduced oilseed crop, besides groundnut, coconut, gingelly, mustard, oil palm, gained momentum due to its short duration, photo period insensitivity, drought tolerance adaptability, low seed rate, high content of quality cooking oil and high oilseed multiplication ratio. One of the most rapidly expanding major oilseed crops in India, sunflower (*Helianthus annuus* (L.)), is sometimes referred to as "Surajmukhi" and is the third most significant oilseed crop globally. Introduced to India in 1969, sunflower is an unconventional oilseed crop , addressing the nation's edible oil deficit, sunflowers can be quite helpful since India is now facing a persistent problem with edible oil scarcity. Vegetable oil production in India is the fourth largest, estimating to be around 14.5% of world area with 6.65% of production and plays second important role in agriculture economy, following the food grains area and production. The oil content in the seeds varies from 35 to 43 per cent. The mono unsaturated fatty acids such as oleic and linoleic acid comprises of about 90 per cent of the total fatty acids in oil and may reduce heart diseases since the oil is rich in poly unsaturated fatty acids like omega-3s and omega-6s and triglycerides with good keeping quality. Sunflower hulls are used in animal feed as a source of roughage, as a fuel to generate steam or electricity and in production of furfuryl and ethyl alcohol.

Sunflower being an important oilseed crop for its premier oil content and manifold uses at both industrial and pharmaceutical importance .The suitability of the crop to fit into any cropping system is an unprecedented example for any crop to stand the testimony of its dimensional growth. From roughly 0.1 million ha in the 1970s to 1.63 million ha in 2002-03, more land was planted with sunflowers (India Stat Agri, 2021). From 1.463 million tonnes in 2007-2008 to 0.23 million tonnes in 2020-21, sunflower production has severely decreased. According to the existing situation in India, sunflower can be grown on 0.228 million hectares, with an annual yield of 0.212 million tonnes and a productivity of 930 kg/ha .Crop diversification is shift from traditional and less remunerative to more remunerative crops. Sunflower can play an important role in crop diversification because of its short duration, photo-insensitive nature, and wide adaptability to different agro-climatic regions (Bhumi reddy, Chandan lal etal, 2022). India shares 1.25 per cent of total area and contributes 0.58per cent production of sunflower in the world (Food and Agricultural Organization, 2021).Similarly 0.29 lakh hectares are under cultivation with an annual production of 0.3 lakh tonnes and per hectare productivity of 1288 kg /ha in Tamil nadu . In comparison to the average productivity of major sunflower producing countries in the world, being 2100 kg/ha, is much lower .This is attributed to the physiological disorder like poor germination percentage and improper filling of seeds which may be overcome by balanced supply of nutrients as one of the means and adoption of integrated nutrient management as well .As sunflower being a cross pollinated crop, honey bees act as important agents for pollination (Kittur and Nazhat,2014) . A viable solution for long-term, commercially viable agriculture under these conditions appears to be integrated soil nutrient management, which calls for a prudent combination of chemical, organic, and bio fertilizers invariably. Increasingly, this means that the use of biofertilizers like Azospirillium and Phosphobacteria as well as organic manures like compost, vermicompost, and farm yard manures is necessary. This perspective led to the setup of an experiment to look at the effects of organic manures, biofertilizers (INM), and inorganic fertilizer (IFM) combined on sunflower growth and production.

Materials and methods:

Field experiment was conducted at the Experimental farm, Bharath Institute of Higher Education and Research, School of Agriculture, Selaiyur, Chennai. The weather of Selaiyur is moderately warm with hot summer months. While the maximum temperature ranges from 27.8 °C to 82.1 °F with an average temperature of 31.4° C to 88.5° F, May is the hottest month of the year likewise at 24.1° C to 75.4° F on average, January is the coldest month of the year. Field experiments were conducted at the experimental farm, Bharath Institute of Higher Education and Research, School of Agriculture, Selaiyur, Chennai during April-June and June –August to evaluate the integrated nutrient management with sunflower + apiary farming system. The experiment was laid out in split plot design with three replications involving two main and nine sub treatments. The variety used was CO4 with duration of 80-85 days and varietal characteristics are given here by in Table :1.The details of the treatment schedule are viz ; M1-Sunflower alone, M2-Sunflower with apiary as Main treatments ; Sub treatments : S1-Control (no fertilizer); S2-100% Recommended dose of fertilizer;S3-100 % Recommended dose of fertilizer +*Azospirillum*; S4-100 % Recommended dose of fertilizer + *Phosphobacteria*; S5-100% recommended dose of fertilizer +Vermicompost; S6-100% Recommended dose of fertilizer + *Azospirillum*+*Phosphobacteria*;S7-100% Recommended dose of fertilizer +Vermicompost+ *Azospirillum*; S8-100% Recommended dose of fertilizer + Vermicompost +*Phosphobacteria;* S9-100 % Recommended dose of fertilizer + Vermicompost + *Azospirillum* + *Phosphobacteria*

The area earmarked for the experiment to be conducted was prepared by deep ploughing with a tractor drawn cultivator until the desirable tilth ,was obtained and levelled thoroughly. A fertilizer schedule of 40 kg N, 20 kg P_2O_5 and 20 kg K_2O was followed, half the dose of nitrogen with entire dose of phosphorus and potash was basally applied and remaining nitrogen was applied as top dressing at 30 DAS. Following the 45x30cm spacing and suggested seed rate for sunflower cv. CO4, two seeds were planted in each hole at a depth of 3 cm. Life irrigation was administered immediately following sowing and again at 3 DAS with scheduled irrigation in accordance with the crop's needs. The treatment schedule specified was closely adhered to as per the design, and the treatment plots of 5x4 sq m size were used. When the capitullum reached physiological maturity, it was harvested, threshed, and sun-dried for three days. The seed output, measured in kg/ha and expressed as 14.5% moisture content, was recorded. Attaining physiological maturity the capitullum was harvested threshed and sundried for three days and seed yield was recorded at 14.5% moisture content and expressed in kg/ha.

The observations were recorded in five sample plants,in each treatment plot for parameters *viz*; plant height, dry matter production at harvest, capitullum diameter, number of seeds/ capitullum, number of filled seeds per capitullum, percentage of filled seeds per capitullum, percentage of filled seeds per capitullum , seed yield, stalk yield, and the data was statistically analyzed as suggested by Panse and Sukhatme and critical differences were arrived at 5% probability level.

Table: 1 Varietal particulars

Variety	CO 4
Parentage	Extract from the cross Dwarf x Surya
Duration	80-85 days
Plant height	145-175 cm
Seed size and colour	Presence of stripes on the seed coat
Head diameter	15-19
Average yield (kg/ha)	
Irrigated	1750
Rain fed	1500
Oil content	39.7
100 seed weight (g)	5.8

Results and discussion:

Several treatments of integrated nutrient management with apiary inclusion led to notable and significant change in several vegetative and physiological growth parameters, yield-attributing features, and sunflower yield, as documented in the present experiment's results. Restoring organic matter to the soil, decreasing the need for inorganic fertilizers, improving nutrient use efficiency, and maintaining the physical, chemical, and biological qualities of the soil are the main goals of integrated plant nutrition systems (IPNS). Despite their potential limitations in terms of nutrient availability, bulky organic manures play a crucial role in achieving the aforementioned goals. (Subbarao and Sammireddy, 2008)

1)**Plant height** : (**Table:2)** All the treatments tried showed significant variations, in plant height at harvest .The treatment involving 100% recommended dose of NPK + Vermi compost @5t/ha + *Azospirillum* + *Phosphobacteria* (S9) had registered the highest plant height of 91.12,160.19,176.45cm and 93.19,163.23,180.43 cm for season I and II respectively. The findings are in conformity with Tharmaraj et al (2011). Application of vermicompost, biofertilizers contribute to better performance of plant growth parameters through higher availability of N, P and K that stimulated cell elongation and plant growth (Sankara Reddy etal;2000; Namitha and Joshi; 2010) . A steady supply of N and P from vermicompost, which may have satisfied N and P requirements in cell elongation and cell division during the early growing period, and later from foliar application at critical stages of plant growth, may be responsible for the increase in height. Rapid mobilization of N, P, and K from inorganic fertilizers may also be a contributing factor. This may be the consequence of P solubilizing bacteria and Azotobacter releasing P and N. There is evidence that higher plant growth is aided by the development of plant growth regulators of the gibberellin and auxin types. The inoculation of Azotobacter exhibited enhanced plant development as a result of the continuous production and release of plant growth chemicals in the rhizosphere. Additionally, it boosted the crop's capacity to absorb nutrients, leading to a greater maximum plant height in M2S9. (Raj and Mallick, 2017 and Mukherjee *et al*., (2019).

2)Dry matter production at harvest : (Table:2) The dry matter production at harvest was significantly influenced by integrated nutrient management practices during both the seasons. Dry matter production of 804,3813.89,5509.18kg/ha and 809,3819.91,5512.20kg/ha was recorded in the treatment involving *azospirillum*, *phosphobacteria* ,vermicompost with recommended dose of fertilizers . Integration of organics induced the secretion of acetic acid, propionic acid in lowering the pH thus favouring the availability of P2O5 that lead to the accumulation of photo synthates ,hence increasing the leaf area index (Alokananda Moitra etal,2012).

3) Yield components:i) Number of seeds per capitulum and filling percentage: The total number of seeds per capitulum **(Fig :1)** and filling percentage **(Fig:2)**was significantly influenced by all the treatments. Among the treatments application of recommended dose of fertilizers+ vermicompost + *azospirillum*+ *phosphobacteria* registered 861.92 and 896.11 and 865.94 and 900.10 in the main treatment control and sunflower + apiary during the I and II seasons respectively. Similarly the percentage of filled seeds **(Fig:2)** also show significant variations in all treatments traced ,among which the application of 100% recommended dose of fertilizers +vermicompost +*azospirillum* + *phosphobacteria* (S9) had recorded 92.1, 96.05 and 95.11, 99.07 in main treatments for season I and II respectively. The better performance of the yield attributes is augmented by the cumulative effect of integration of inorganic, organic amendments and apiary on sunflower. Moreover the pronounced effects on soil organic matter replenishment, better translocation of nutrients to the sink had gained advantage which is in conformity with Venkatakrishnan and Balasubramaniam (1996) and Alokananda Moitra etal, (2012) According to Reddy et al. (2005), the outcomes are consistent. Higher availability of P and N had concurrently improved nutrition from an early stage of growth could be the likely cause of the highest yield-attributing characteristics. The generative growth of sunflowers resulted in a notable rise in the number of seeds per head and head diameter, indicating the significant role played by bio fertilizers and vermi compost in it. According to research by Tohidi-Moghaddam et al. (2004), azotobacters fix atmospheric nitrogen and make it available to plants, while phosphorus solubilizing organisms (PSB) raise the amount of phosphorus that is available in the soil, potentially increasing the number of seeds in seeds. When 50% RDF was applied along with vermicompost, and biofertilizers the result was higher seed yield than when other nutrient management treatments and control. The positive impact of biofertilizer may be attributed to phosphate-solubilizing bacteria's solubilization of P and biological N fixing (Raj and Mallick, 2017; Mukherjee et al., 2019). Seed yield is controlled by a large number of internal and external factors and any variation in them is liable to bring about variation in yield. Final achene yield is a cumulative effect of various yield components like head diameter, number of achenes per head and 1000- significantlyseed weight.Azole-fixing bacteria azotobacter also increased plant growth and yield due to luxuriant vegetative growth, and microorganisms with phosphate solubilizing potential increased the availability of soluble phosphate and enhanced plant growth and yield due to better root growth and increased uptake of nutrients (Ponmurugan and Gopi, 2006).

ii) Seed yield: **(Fig:3)** Treatment with apiary combination showed a significant influence on seed yield of sunflower compared to treatment with sunflower alone, as the bees pollinate each and every head, as they are the good pollinators and travellers (Kittur Nazhat, 2014). There are several types of insects which are considered highly efficient in pollinating flowers, and honeybees are one of them, because honeybees depend completely on the flowers in feeding In addition, honeybees are easy to raise in large numbers, which is often done in cells that can be moved from one place to another. Furthermore, it is quite possible to direct honeybees to feed on specific type of flowers [Khanbash,1996]. And the highest seed yield recorded from treatment S9 (100% RDF + Vermicompost + *Azospirillum* + *Phosphobacteria*) of 1456.22 (M1), 1689.03 (M2) kg ha-1 in first season and 1461.20 (M1), 1694.08 (M2) kg ha-1 during second season **(Fig: 3)** and the lowest seed yield was recorded under the S1 (control). Besides a healthy environment , a good head start and vigour initiated , led to higher yield as reported by Pazhaniraja and Prabudoss (2014) with beneficial organisms. In fact the bee pollination in sunflower have increased seed yield by 56-75% (Greenleaf and Kremen,2006 and Kittur Nazhat,2014). The pollinated plants gave the best results for the traits studied, which confirms the importance and role of bees in the quantity and quality of crop production, especially the sunflower crop.The increase of honeybee colonies in the sunflower field during the flowering period leads to improve quality and quantity yield of sunflower. Several studies proved the positive impact of honeybees on increasing the oil content of sunflower seeds. Studies indicated that hybrid seeds were produced through bee pollination, as well as manual pollination, maintained their superiority with higher yield (Batol Abdulla Karso etal;2023) The increased availability of essential nutrients from the integration of chemical fertilizer, organic manure, and biofertilizer is therefore thought to be the cause of the improved growth, enhanced yield attributes, and final seed yield of sunflower under reduced rate of RDF at 50% in conjunction with organic manure and biofertilizers. The results closely align with previous research conducted by Jeyabal et al. (2000), Raj and Mallick (2017), and Mukherjee et al. (2019).

Conclusion :

Adoption of integrated nutrient management practices in sunflower including apiary have proved sustainability through enhanced productivity and soil fertility as well ,with added income generation through honey output also. Perhaps, it holds promise for an ecofriendly, agronomically sound and economically viable for the marginal, small and big farmers too. Realising the potential of harmonious performance due to the integration of sunflower + apiary in combination with organic and inorganic amendment a more secured production of sunflower crop and honey production provides promising returns for livelihood security . Apparently the adoption of the best practice inferred from the finding hold favourable results thus assuring better livelihood options for the upland farmers . In order to address the increasing nutrient demand of contemporary agriculture, integrated nutrient management holds out a lot of potential. Additionally, it can support sustainable production without degrading crop output or soil health. According to the results of the current field experiment, the best way to increase sunflower production was to apply all three of the nutrient sources together with the apiary (M2) treatment through bee pollination. Additionally, this experiment demonstrated that vermicompost outperformed farm yard manure as the two organic sources of plant nutrients. Consequently, this combination of nutritional sources may be a better way for sunflowers to manage their nutrient intake. Cooperation between farmers and beekeepers in areas where hives can be moved to fields can benefit both parties by giving the farmers' field more productivity and supply food for the bees. One of the most important ways to conserve pollinators, particularly honeybees, is to educate farmers and consumers about the process of pollination. This will help to lower the cost of food production and contribute to global food security.

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Table: 1 Influence of integrated nutrient management with sunflower +apiary systems on plant height (cm) and DMP(kg/ha) at harvest

Sub Plot Treatment	Plant height(cm)						DMP(kg/ha)					
	First Season			Second Season			First Season			Second Season		
	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean	M_1	M_2	Mean
S_1	81.39	84.74	83.06	85.41	88.72	87.06	1448.50	1515.98	1482.24	1451.56	1518.96	1483.76
S_2	139.78	149.81	144.29	143.80	153.80	148.8	2537.99	2648.12	2593.05	2540.97	2651.17	2596.07
S_3	142.12	155.02	148.57	146.16	159.06	152.61	4335.91	4506.82	4421.36	4338.95	4509.84	4424.39
S_4	144.06	156.03	150.04	148.09	160.12	154.10	4335.96	4512.90	4424.43	4338.99	4515.93	4427.46
S_5	145.34	160.67	153.00	149.35	164.69	157.02	4720.74	4905.96	4813..35	4723.75	4908.99	4816.37
S_6	152.23	164.90	158.056	156.26	168.94	162.6	4887.60	5044.96	4966.28	4890.61	5047.07	4968.84
S_7	157.01	167.64	159.35	161.03	171.63	166.33	5037.63	5060.42	5049.02	5040.69	5063.49	5052.09
S_8	164.55	170.45	167.50	168.53	174.49	171.51	5131.58	5327.86	5229.72	5134.60	5330.89	5232.74
S_9	169.84	176.45	173.14	173.86	180.43	177.14	5264.73	5509.18	5401.95	5394.76	5512.20	5453.48
Mean	144.03	153.96		148.05	157.98		4192.29	4336.91		4206.09	4339.83	

Plant height	Main	Sub	MXS	SXM	Main	Sub	MXS	SXM	DMP	Main	Sub	MXS	SXM	Main	Sub	MXS	SXM
SED	0.14	0.73	1.39	1.04	0.17	0.75	1.42	1.06	**SED**	7.74	1.55	2.95	2.19	7.76	1.58	2.98	2.22
CD (p=0.05)	0.28	1.47	2.79	2.08	0.34	1.51	2.84	2.13	**CD (p=0.05)**	15.48	3.11	5.91	4.39	15.53	3.16	5.96	4.44

Fig. 1 Number of seeds per capitulum (first and second season)

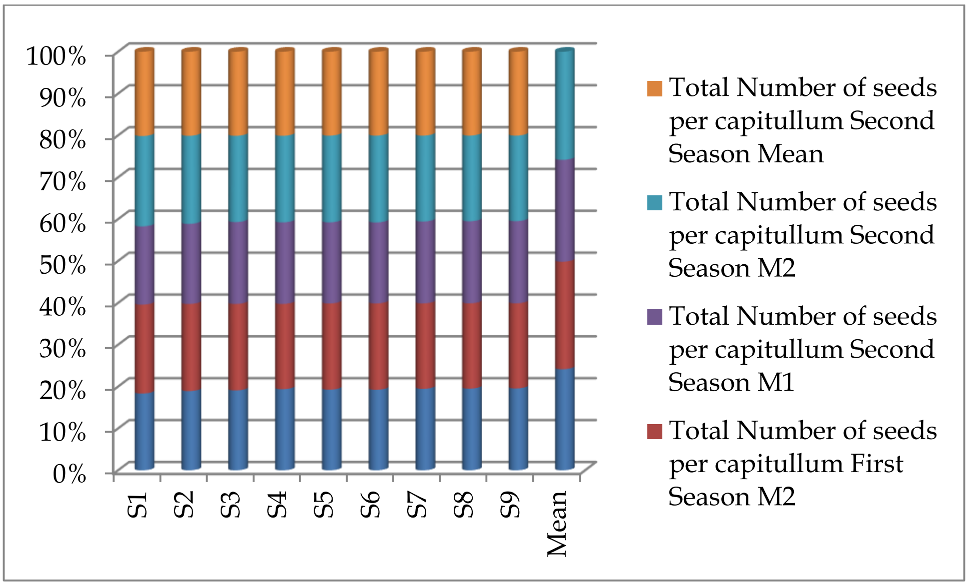

Fig. 2 Percentage of filled seeds (first and second season)

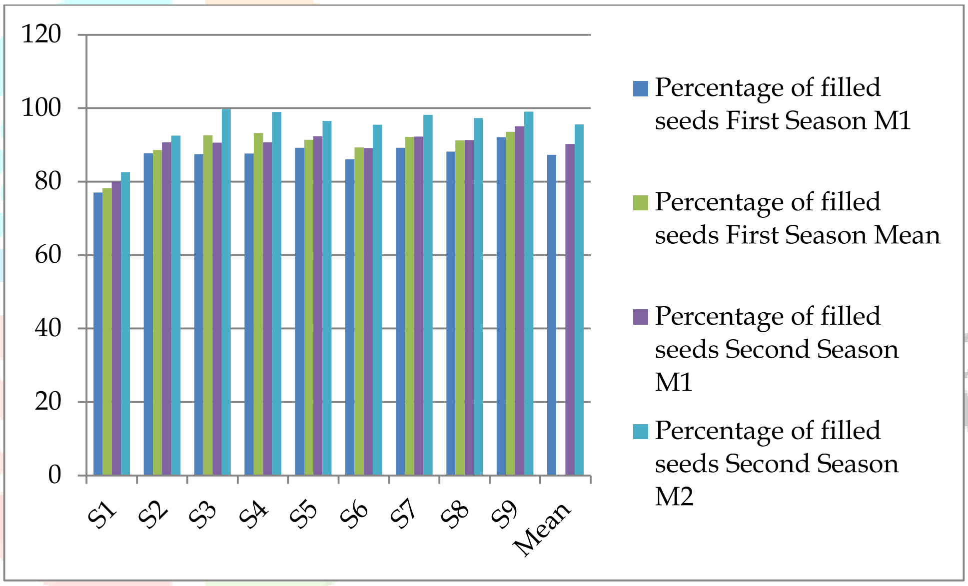

Fig 3: Seed yield kg/ha (first and second season)