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Research Article

Impact Assessment of Bio-Pest Repellents and Bio-Fertilizers on the Production and Economics: Chickpea Field

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Abstract

The primary aim of conducting this study is to evaluate the economic viability, crop health, and grain quality parameters and potential for farmers of dollar chickpea cultivation through a comprehensive cost-benefit analysis (CBA). Additionally, the aim is to reduce the input cost, evaluate crop health, grain quality and increase productivity. Dollar chickpea, known for its resilience and nutritional value, has garnered increasing attention among agricultural communities. Utilizing primary data collected from demonstrations on three plots of farmers using different agronomic practices. The study examines the costs associated with cultivation, including inputs such as seeds, fertilizers, pesticides, labour, and machinery, as well as operational expenses. Concurrently, the benefits derived from dollar chickpea production are evaluated, encompassing market prices, yield levels, and potential income generation. The analysis integrates both direct and indirect costs and benefits, incorporating factors such as yield variability, market fluctuations, agroecosystem analysis and environmental externalities. Findings reveal a favourable cost-benefit ratio for dollar chickpea cultivation across various contexts, indicating its potential as a profitable crop option for farmers. The study further highlights the importance of adopting sustainable practices and technological innovations to optimize production efficiency and mitigate risks. Overall, this research contributes to the understanding of the economic and ecological dynamics surrounding dollar chickpea cultivation, offering insights to promote sustainable agriculture and rural development.

Keywords: Bio-Pest; Repellents; Bio-Fertilizers; Economics; Chickpea Field

Introduction

Samaj Pragati Sahayog (SPS) is a non-profit, and a grass root initiative that works in India's most backward districts, mainly in the central Indian Adivasi belt. We work in the drought-prone, tribal areas of Madhya Pradesh, which typifies few of the most difficult problems facing the country. Characterised by low incomes, high poverty, poor human development indicators like female literacy and infant mortality rates, the tribal communities of the region are highly vulnerable to climate variability and climate change. The main aim of the study is to promote sustainable agriculture techniques and improve soil health to enhance crop productivity as well as reduce the cost of inputs……….NPM details [22] Chickpeas (Cicer arietinum) are the annual legumes of the family Fabaceae. India accounts for 68% of the total global output of chickpeas, and incidentally, it is one of the largest consumers and a very high-value crop. Dollar chickpea is a larger, cream coloured variety of a chickpea with a rounder shape majorly known as 'Kabuli chana' generally more expensive (hence the name "dollar") Besides being a very rich source of protein, it also maintains soil fertility through biological nitrogen fixation [23]. Dollar chickpea is often grown by small and marginal farmers in soils poor in fertility and low moisture retention. Factors such as its indeterminate growth habit, prolonged flowering, flower drop, and pod shattering contribute to low yields, and it is grown often cultivated without adequate fertilizer doses, irrigation or essential agronomic practices (Ullah et al., 2023b).

In the present scenario, there is a scope for increasing the production of dollar chickpea by reducing the production losses caused by serious pests, diseases, inadequate doses of fertilizers, and unbalanced nutrient management [21]. Therefore, this study seeks to explore both economic and agronomic dimensions of dollar chickpea cultivation under varied conditions, contributing to improved decision-making for smallholder farmers.

Soil testing

Tested same farmer plot in two different seasons, of Laundee village to understand the soil nutrient status, in the sample we tested primary nutrients like Nitrogen (N), Phosphorus (P), and Potassium (K) along with soil organic carbon (OC), potential of Hydrogen (pH), electrical conductivity (EC), and some of the selected secondary and micro – nutrients such as sulphur (S), Iron (Fe), Zinc (Zn) etc [9].

Soil in the selected village have Neutral in nature. Will be studying all the micro and macro nutrients in three conjunctive years to understand the soil nature in the Laundee village.

Based on the soil test results plot and crop specific recommendations on nutrient management preferably through organic were reported in soil test report and given to the farmer [17].

Crop demonstration

SPS has conducted field demonstrations on dollar chickpea crop in the rabi season, in the year 2023-24. Farmer's plots of about 0.62 acres for each demonstration. With the premise that "seeing is believing" farmers are encouraged to adopt NPM agriculture, nature-positive management [16].

Types of crop demonstration

- NPM demonstration with microbial solution
- NPM demonstration with adequate use of Chemical fertilizers
- Farmers practice plot

NPM demonstration with microbial solution

- Seed treatment with Bio-fertilizer
- Use of organic manure and soil application solution (Applying soil application solution to analysis the production and quality parameter to understand the difference between chemical fertilizers and the solution)
- Use of 80% compost and 20% vermicompost to supply recommended nutrient
- Eco- Friendly pest and disease management

NPM crop demonstration

- Seed treatment with bio fertilizers
- Adequate doses of synthetic fertilizers for nutrient sufficiency
- Eco friendly pest and disease control
- Hand weeding for weed management

Farmers' practice demonstration

The plots under this treatment were managed as per the current farmers' practice in the region, with the same fertilizer source and crop protection treatments as being applied by local farmers.

Figure a

Elements	Unit	Rabi 23-24	Summar 23-24	Remark
pH	-	8.27	7.83	Neutral
EC (ds/m)	M.m./c.m.	0.89	0.2	Normal
OC	Percentage	0.39	0.56	Low availability of OC
N	Kg/hec	176	196	Low Nitrogen availability
P	Kg/hec	19.09	21.12	Average availability of phosphorus in the soil
K	Kg/hec	414	396	Very high potassium availability
S	PPM	15.13	18.11	Rich in sulphur
B	PPM	0.61	0.85	Rich in boron
Zn	PPM	0.95	0.51	Rich in Zinc
Fe	PPM	8.21	7.97	High Iron availability
Mn	PPM	2.55	3.77	Rich in manganese
Cu	PPM	0.95	0.37	Rich in copper

Table 1: Soil fertility status of plot in laundee village.
Farmer Name: Kanchan W/O Santosh
Practices followed by farmers in previous year: NPM (Nature-positive management).

Date of sowing in both the NPM demonstration is 18/11/23 and in farmer practice demonstration is 12/11/23, Table 02 contains all the agronomic practices followed in all three demonstrations.

Physical parameter assessment: To understand the plant physical parameters, in each field we have used the CESA (crop ecosystem analysis) methodology to analyse the crop heath and production by selecting one plant on five footstep (5 feet inside the border) diagonally. At each spot will select diagonally 10 plants for recording observation (20 plants/spot).

Insect and pest attack assessment: To assess insect and pest attack on the crop we have used CESA methodology to analyse the damage or infestation, by selecting 10 plants diagonally on five footsteps. While taking an observation we have focused on the pest infestation on crop.

Particular	NPM with microbial solution	NPM with Synthetic fertilizers	Farmers' practice
Area	0.62 acre	0.62 acre	0.62 acre
Variety	Local	Local	Local
Seed rate in kg	25	25	40
Seed treatment	Trichoderma Viridi @500gm for 25kg of seed	Trichoderma Viridi @500gm for 25kg of seed	warden (thiamethoxam and fipronil) insecticide @200ml for 40 kg of seed
Trap crop and border crop	Sunflower, coriander, sesamum	Sunflower, coriander, sesamum	Trap crop and border crop were not sown
Method of sowing	Hand sowing by labours	Hand sowing by labours	Drilling
Plant spacing (cm)	45*15	45*15	45*15
Nutrient management	* Compost 100 kg with vermicompost 50 kg and 1.5 kg Trichoderma	* Compost 100 kg with vermicompost 50 kg and 1.5 kg Trichoderma	DAP + Urea (25 and 50 kg respectively)
	* Application of soil application (Micro and macro nutrient mixture) @3lit	* 50kg single super phosphate application by broadcasting method	19:19:19 application (N:P:K)
	*Spray of soya tonic (an organic growth promoter) at the time of flowering @2lit	*Spray of soya tonic at the time of flowering @2lit	
Pest management	* Spray of Chaar chatani ark (a bio pest repellent) at 21 DAS	* Spray of Chaar chatani ark at 21 DAS	Spray of pesticides and insecticides three times
	*Spray of foliar application (a diluted solution of biological agents) @2.5lit at 55 DAS	*Spray of foliar application @2.5lit at 55 DAS	Use of fungicide
	*Spray of neem oil (botanical extract) 0.5 lit at 65 DAS	*Spray of neem oil 0.5 lit at 65 DAS	
	*Use of pheromone traps, yellow sticky traps and t- guard	*Use of pheromone traps, yellow sticky traps and t- guard	
Disease management	No control measures followed	No control measures followed	
Weed management	Hand weeding by labours	Hand weeding by labours	Dora @2times
	Dora (Manual weeder) @3 times	Dora @3 times	
Irrigation	* First irrigation after sowing	* First irrigation after sowing	*First irrigation at 15 days before sowing
	* Second irrigation at 30 DAS	* Second irrigation at 30 DAS	*Second irrigation at 1 DAS
			*Third irrigation at 30-35 DAS

Table 2: Agro techniques followed in Chickpea crop demonstrations in different treatments.

SUMMARY OF OBSERVATIONS OF YIELD PARAMETERS															
S.No	Date of Observation	Age of Crop-DAS	NPM plot with Synthetic fertilizers -0.62 acre				NPM Plot with microbial solution -0.62 acre				Age of Crop-DAS	Farmer practice plot-0.62 acre			
			Avg. Plant Ht-cm	Avg. No of Branches	Avg. No of Flower	Avg. No of Fruits	Avg. Plant Ht-cm	Avg. No of Branches	Avg. No of Flower	Avg. No of Fruits		Avg. Plant Ht-cm	Avg. No of Branches	Avg. No. of Flower	Avg. No of Fruits
1	28/12/23	40	35.6	5.95	1.9	0	33	4	0.8	0	57	38	5	6	0
2	10/1/24	59	46.95	7.35	1.1	0	47	5.1	5.7	0.8	66	56	5	5.1	1
3	29/1/24	78	46.75	7.45	2.4	2.9	47	5.3	13	2.7	85	57	5.1	2.8	3
4	21/2/24	101	NA	NA	NA	69	NA	NA	NA	67	108	NA	NA	NA	34

Table 3: Contains all the physical parameter records taken by our team to understand the physical health of a crop.

S.No	Date of Observation	Age of Crop-DAS	NPM plot with Synthetic fertilizers -0.62 acre			NPM Plot with microbial solution -0.62 acre			Age of Crop-DAS	Farmer practice plot-0.62 acre		
			Avg. No of pest	Major attack on	Crop health status	Avg. No of pest	Major attack on	Crop health status		Avg. no of pest	Major attack on	Crop health status
1	28/12/23	40	5	moderate leaves	Average	3	Moderate leaves	Good	57	4.7	Moderate leaves	Average
2	10/1/2024	59	3.6	Leaves and pods	Good	4.2	Leaves and pods	Good	66	5.2	Pods and leaves	Average
3	29/1/24	78	7.1	Pods	Average	6.3	Pods	Average	85	4.2	Pods	Average
4	21/2/24	101	1	Pods	Good	1	Pods	Good	108	0	NA	Good

Table 4: Summary of observations of pest infestation.

Cost of cultivation: To calculate the cost of cultivation we have focused on all the variables as required input and their cost including manpower, machinery and other fixed cost in all three treatments, and to calculate net income we have calculated the benefit-cost ratio

Cost of cultivation of all three demonstration:

Dollar chickpea

Sampling data: To understand the quality of the produce, we have done the sampling of 100 gm samples mentioned in the table 6.

As per the quality parameter produce was priced, mentioned in the table 05.

Sr. No.	Parameter	NPM with synthetic fertilizer	NPM with microbial solution	Farmer practice data
1	Broken (gm)	2.33	2.51	9.56
2	Foreign matter (gm)	0	1.91	1.13
3	Discolour (gm)	1.71	2.23	6.01
4	Undersize or shrivelled (gm)	11.71	4.08	25.29
5	Count (number)	85-94	70-80	60-70
6	count Weight (gm)	55.19	50.34	57.72

Table 6: Sampling data of 100 gm sample.

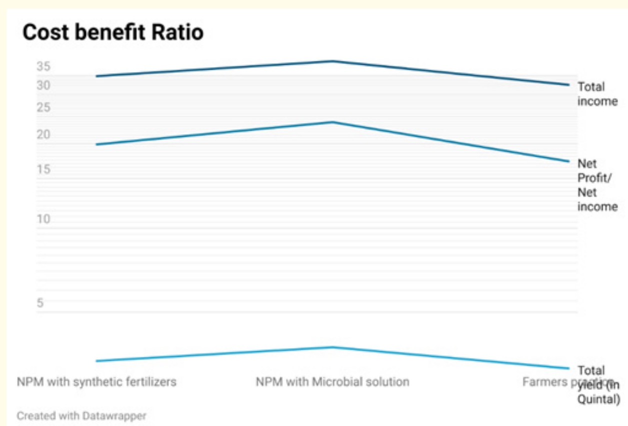

Figure b

Figure 1: NPM with microbial solution

Figure 2: NPM with Synthetic fertilizers.

Figure 3: NPM with Synthetic fertilizers.

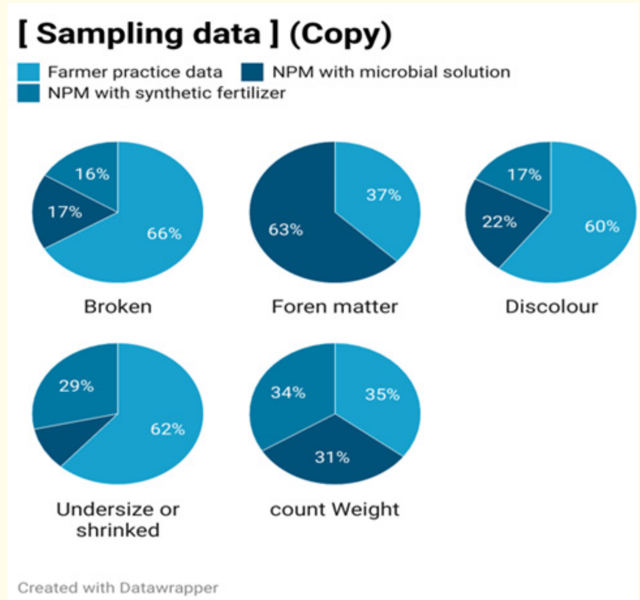

Figure c

Formulas used to calculate all the data

- Total cost of cultivation = Total variable cost + Total fixed cost.
- Total Income = Yield (kg) × Market price of the crop (Rs./kg)
- Net Profit = Total Income - Total cost of cultivation.
- Benefit cost Ratio = Total Income/Cost of cultivation.
- Interpretation: If BCR is >1 than the project is profitable and benefits are greater than cost.

Result and Discussion

The data in table 05 indicates that the average grain yield of dollar chickpea in NPM with microbial solution is higher as compared to both NPM with synthetic fertilizers and the Farmer practice plot. It means that the average grain yield of dollar chickpea increases by 12% over the commercial farmer practice methods. It shows that microbial applications improve soil health, nutrient cycling, and enhance plant growth more effectively than synthetic inputs alone.

One of the critical factors influencing performance in the trial was crop intensification. The seed rate in the farmer practice plot was much higher than the other two demonstrations, which led to higher density and limited space. Plants in the farmer practice plot received less aeration and space to spread their branches, resulting in thicker stems. This condition negatively impacted the development of pods and fruits, resulting in fewer pods per plant as indicated in table 03. Additionally, table 03 also indicates that, the average number of flowers was initially higher in the farmer practice plot, but with time they dropped and at the time of pod filling the remaining flowers in the farmer practice plot were fewer than the other two plots.

Table 06, presents the sampling data for 100gm harvested dollar chickpea, shows that the farmer practice plot had the highest broken grain, indicating poor post-harvest handling. While NPM with microbial solution and NPM with synthetic fertilizer had fewer broken grains, reflecting better grain integrity. Additionally, discoloration was highest in the farmer practice plot, due to potential pest impact, which ultimately affected the quality of the produce and led to a lower market price. Undersized and shrivelled grains were also high in the farmer practice plot, indicating a stressed crop, in contrast, NPM plots had less undersized and shrivelled grains, indicating healthier and well-developed grains. Count weight was higher in farmer practice plot, but it was associated with more shrivelled, broken and discoloued grains. While the NPM plots had a balanced count weight.

The data in table 04 indicates that the average pest infestation in Farmer practice plot were much higher in the first two observations due to heavy doses of synthetic fertilizers and denser crop canopy, while it was less in last two observations due to pesticide spray. In NPM plots, pest infestation was gradually decreasing due to continues sprays of jaivik dawai and IPM activity as per the recommendation. The gradual decline in pest population in NPM plots indicates the long-term benefit of preventive and ecological pest management, which is less reliant on chemical pesticides.

Furthermore, climatic conditions during the trial were humid, and regular rainfall during the time of pod filling and flowering, increased pest attack across all plots. However, NPM plots were more resilient, likely due to the incorporation of trap and border crops, improved soil health, microbial activities, and balanced and ecological pest management.

Figure 4: Farmer practice plot.

Figure 5: NPM with Synthetic fertilizers.

Figure 6: NPM with Synthetic fertilizers.

Conclusion

The findings from this small-scale study clearly demonstrate the agronomic, economic and ecological advantages of nature-positive management. The NPM approach led to improved grain yield, low input cost, better grain quality and effective pest control. This approach not only reduced the reliance on chemical pesticides but also enhanced crop resilience under adverse weather conditions. Additionally, it increased the yield with better quality of grain, which ultimately led to better market price. Given the positive outcomes observed in overall factors, this pilot trial supports the effectiveness of microbial inputs. However, as this was a limited scale study, we recommend that these findings be validated at a larger scale across diverse agro-climatic zones and soil conditions, to better assess the adaptability of the model. The use of same package of practices, optimized seed rate, microbial solutions, and ecological designs can serve as a sustainable pathway towards improving dollar chickpea productivity while ensuring long term soil and crop health.

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