

RESEARCH PAPER

Yield and economics of soybean (*Glycine max*) as influenced by natural and organic farming practices and foliar application of liquid organic manures (LOM's)

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Abstract: The experiment was carried out at Main Agricultural Research Station, UAS, Dharwad, during *kharif*, 2022-23 and 2023-24 with an aim to find out the insights into sustainable management strategies for soybean cultivation, balancing productivity with ecological conservation. The experiment consists of 3 main plots in Strip-I (organic, natural and integrated farming) and five liquid organic manures (LOM's) in strip-II (vermiwash @ 5%, jeevamrutha @ 20%, panchagavya @ 5%, cow urine @ 10% and water spray). The field had been passed through the transitional period of three years which is essential to convert into chemical free farming. On pooled basis, the results were among the treatment interactions, recommended package of practices (RPP) recorded higher grain and straw yield (3901 and 5914 kg per ha, respectively) than other treatments. Among treatment combinations, organic farming with panchagavya (A₂B₂) were recorded seed & haulm yields (3845 and 6559 kg per ha, respectively) which were statically on par with RPP. Net returns and B: C ratio were higher with RPP and followed by CF, NF, INF and OF. A higher B: C ratio was reported by natural farming with panchagavya (A₁B₂) (3.96) next to RPP.

Key words: Economics, Integrated natural farming, Natural farming, Organic farming, Soybean, Uptake, Yield

Introduction

The introduction of green revolution technologies in India, leads to increased food production during 1960's. On the other side, soil, water and air get polluted due to use of inorganic fertilizers and pesticides. Inorganic fertilizers damaged the soil physical properties like water holding capacity, water retention, aggregate stability and chemical properties by increasing the soil alkalinity and salinity (Vinay *et al.*, 2020). Hence, now a days policy makers looking for alternate eco friendly farming practices which makes the soil fertile and minimal pollution to the environment. Eco friendly farming meets the needs of existing and future generations, while also ensuring profitability, environmental health, social and economic equity (Lunagarria and Zinzala 2017). It favours techniques that emulate nature to preserve soil fertility, prevent water pollution and protect biodiversity. Eco-friendly farming practices offer a solution to various problems like food insecurity, farmer's distress, health problems arising due to pesticide and fertilizer residue in food and water, environmental safety, biodegradation of agricultural wastes, global warming, climate change and natural calamities (Meena *et al.*, 2016). It has also a potential to generate employment, thereby stemming the migration of rural youth. With this information, the present study is conducted in soybean (*Glycine max*) to assess few eco friendly farming practices *viz.*, organic farming, natural farming and combination of both in terms of productivity, economics and nutrient uptake. Similarly, foliar application of liquid organic manures (LOM's) *viz.*, vermiwash, panchagavya, jeevamrutha and cow urine were assessed by how much yield reduction will be minimized by avoiding nutrient deficiency at critical stages of crop growth.

Soybean (*Glycine max*) is a well known oil seed as well as pulse crop belongs to family *Fabaceae* and sub family *Papilionaceae* having center of origin at South East Asia. Soybean is also called as 'golden bean', contains 40% good quality protein, rich in lysine and 20% oil high in essential fatty acids (Omega-6 and Omega-3). Additionally 26%t carbohydrates, 4% minerals, 2% phospholipids, vitamin A, B, C, D, E and K are also contained. Soybean is rich and cheapest source of protein and fat, having multiple uses as food. In India, soybean has emerged as main oilseed crop in a short span of time. It is termed as wonder crop because soybean being natural biological nitrogen fixer in the field that plays a vital role in increasing indigenous nitrogen fixation in soil (40 kg per ha) (Kumar, 2022). The study was conducted with an objective of finding the influence of different farming practices and foliar sprays of liquid organic manures on productivity, economics and plant macro and micro nutrient uptake as well as reducing the yield losses in pure natural farming and organic farming practices.

Material and methods

The experiment was laid out in strip plot design with three replications on vertisols of northern transitional zone of Karnataka (Zone- 8). The experiment was conducted with 'Dsb-34' variety with a spacing of 30 × 10 cm during *kharif*, 2022-23 and 2023-24 on permanent plots in both the years. Strip-I consisting of three farming practices *viz.*, natural farming (NF), intensification of natural farming with organic farming practices (INF), organic farming (OF) and strip-II consisting of foliar

application of liquid organic manures viz., vermiwash (VW) @ 10%, panchagavya (PG) @ 5%, jeevamrutha (JA) @ 20%, cow urine (CU) @ 10% and water spray (WS) as control along with two un even controls namely recommended package of practices (RPP) of UAS, Dharwad and chemical farming (CF). The foliar applications were done during crop growth stages viz., seedling stage, bud formation & flowering stage, pod formation stage and pod development stage. In natural farming (NF) the seeds were treated with *beejamrutha* before sowing and *Jeevamrutha* sprinkled on soil and crops at 21 days interval @ 500 l per ha from 21 DAS to 90 DAS (4 times). Exsitu green manuring of *Glyricidia* was grown on bunds and used as mulch at 30 DAS. The pest and diseases were controlled through *neemastra*, *agniastra*, *dashparni*, *shuntiastra* and sour butter milk. In integrated natural farming (INF) in addition to natural farming practices 50% of the organic manures (equivalent to 50% RDP applied in organic farming) were added. In organic farming the seeds were treated with *Rhizobium* and Phosphorus solubilizing bacteria (PSB) (1250 g each per ha) at the time of sowing. Addition of FYM @ 6.0 t per ha + organic manures were supplied equivalent to 100% RDP through FYM (8.7 t per ha) and vermicompost (5.6 t per ha) @ 50% each, in addition to recommended dose of FYM. In recommended package of practices (RPP) the seeds were treated with *Rhizobium* and *Phosphorous solubilising bacteria* (1250 g per ha each). Recommended dose of fertilizers were applied @ 40: 80: 25 kg N:P₂O₅: K₂O along with FYM @ 6 t per ha and ZnSO₄ @ 12.5 kg per ha incorporated in to the soil. In chemical farming (CF), seeds were treated with vitavax @ 2 g per kg of seed and soil application of 40: 80: 25 kg N:P₂O₅: K₂O was followed. All the fertilizers were applied at the time of sowing in RPP and chemical farming. Foliar application of liquid organic manures (LOM's) were done as per the treatments in organic farming, natural farming and integrated natural farming at different critical stages.

The Seed yield and Haulm yield per plot was recorded separately and expressed as kg per ha. Harvest index (%) was calculated by dividing economic yield with total biological yield which included grain and stover (Donald, 1962).

Weather and soil data during crop growth period:

The rainfall received during the experimental year (*khariif*, 2022 and *khariif*, 2023) was 1101.60 mm & 507.00 mm which was 26.01 per cent more than & 37.79 per cent less than the mean annual rainfall for the past 73 years (1950-2023) (814.99 mm) respectively. The total rainfall during soybean crop growth period of 2022 (27th standard week to 39th standard week) was 494.40 mm in 39 rainy days and higher rainfall received in the 35th standard week. During 2023 (27th standard week to 39th standard week) was 345.61 mm in 22 rainy days and higher rainfall received in the 30th standard week. The weather parameters were optimum for growth and development of crop hence yielded normally. Overall, during the experimental period crop was not subjected to stress.

The Experiment was conducted on vertisol with a P^H 7.03, EC 0.123 ds m⁻¹, organic carbon content 6.09 g kg⁻¹, Available

Nitrogen (244.16 kg ha⁻¹), Available Phosphorus (43.45 kg ha⁻¹) and Available Potassium (353.65 kg ha⁻¹) were low, medium and high in range, respectively. The data recorded on various parameters of crop during the course of investigation was statistically analyzed by following the analysis of variance for strip plot design as suggested by Panse and Sukhatme (1985). Statistical significance was tested with 'F' test at 5% level of probability and compared the treatment means with critical difference. Means followed by the same letters do not differ significantly by DMRT at P=0.05.

Results and discussion

Seed, Haulm yields & Harvest index

Among the different farming practices, organic farming (OF) recorded higher seed yield and haulm yield on pooled basis (2977 & 4808 kg per ha, respectively) than integrated natural farming (INF) (2703 & 3752 kg per ha, respectively) and natural farming (NF) (2566 & 3136 kg per ha, respectively) (Table 1). INF and NF registered 9.20 and 13.80 per cent lower seed yields than OF. The addition of FYM and vermi compost releases the nutrients like N, P, K and enhances growth as it contain several enzymes, plant growth hormones like, cytokinins, gibberlins and vitamins along with micro and macro nutrients (Jaggi *et al.*, 2023). These added nutrients resulted in higher seed yield and haulm yields. *Panchagavya* @ 5% application increased 6.43, 10.45, 13.17 & 21.07 per cent seed yield and 5.22, 5.32, 10.10 & 16.24 haulm yield over *jeevamrutha*, cow urine, vermi wash and control treatments, respectively. *Panchagavya* application improves the soil rhizosphere through release of growth enhancing enzymes and leads to mobilization and solubilization of nutrients and made available for the plant uptake (Vinay *et al.*, 2020). Increased plant uptake resulted in enhanced yield attributes and ultimately resulted in yield. This result was ratified with the finding of Aher *et al.* (2019) that, the treatments receiving organic manure along with *panchagavya* increased soybean seed yield by 9-13% over RDF.

Higher seed yield & haulm yield (3322 & 5281 kg per ha) were recorded in RPP than all other treatment combinations. However, the best treatment combination *i.e.* organic farming with *panchagavya* @ 5% registered similar values of seed & haulm yields (3250 & 5180 kg per ha) as RPP. The organic and natural farming practices resulted in lower yields when compared to recommended package of practices (RPP) because, although organic manures contain nutrients, they are slowly and less readily available to crops, leading to nutrient deficiencies during the early stages of growth (Varsha *et al.*, 2022). In RPP, both combined application of chemical fertilizers and FYM leads to readily available the nutrients for entire crop growth period without shortage (Jaggi *et al.*, 2023). The harvest index values were higher in natural farming than organic farming and integrated natural farming. The harvest index values were higher with *panchagavya* (40.64%) application and on par with cow urine (40.55%) application. Among the interactions, it was higher with natural farming with cow urine @ 10% (43.39%) when compared to RPP (38.64%) & CF (38.87%).

Table 1. Seed yield, haulm yield (kg ha⁻¹) and harvest index (%) of soybean as influenced by natural, organic and integrated natural farming practices and foliar application of liquid organic manures

Treatment:		(Pooled data)											
→ Farming practices		Seed yield (kg ha ⁻¹)				Haulm yield (kg ha ⁻¹)				Harvest index (%)			
↓ LOM's		A ₁ : NF	A ₂ : OF	A ₃ : INF	Mean	A ₁ : NF	A ₂ : OF	A ₃ : INF	Mean	A ₁ : NF	A ₂ : OF	A ₃ : INF	Mean
B ₁ : Vermiwash @ 10%		2436 ⁱ	2919 ^c	2619 ^h	2658 ^c	3049 ^h	4502 ^b	3801 ^{dc}	3784 ^c	40.94 ^{bc}	39.00 ^{cd}	36.11 ^c	38.69 ^b
B ₂ : Panchagavya @ 5%		2884 ^{c-c}	3250 ^a	3049 ^b	3061 ^a	3448 ^{c-g}	5180 ^a	3997 ^{cd}	4209 ^a	42.88 ^{ab}	38.17 ^{dc}	40.86 ^{bc}	40.64 ^a
B ₃ : Jeevamrutha @ 20%		2508 ⁱ	2917 ^{cd}	2799 ^{c-g}	2741 ^{bc}	3199 th	5094 ^a	3662 ^{dc}	3985 ^b	40.57 ^{bc}	35.82 ^c	39.17 ^{cd}	38.52 ^b
B ₄ : Cow urine @ 10%		2699 ^{gh}	3043 ^b	2850 ^{c-f}	2864 ^b	3112 ^{gh}	5063 ^a	3792 ^{dc}	3989 ^b	43.39 ^a	37.03 ^{dc}	41.23 ^{abc}	40.55 ^a
B ₅ : Water spray (control)		2300 ^j	2753 ^{fg}	2197 ^j	2416 ^d	2871 ^h	4202 ^{bc}	3507 ^{cf}	3526 ^d	40.80 ^{bc}	36.17 ^c	37.47 ^{dc}	38.15 ^b
Mean		2566 ^e	2977 ^a	2703 ^b		3136 ^e	4808 ^a	3752 ^b		41.72 ^a	37.24 ^c	38.97 ^b	
Sources of variation		S.Em±			C.D at 5%	S.Em±			C.D at 5%	S.Em±			C.D at 5%
A		47			130	133			370	0.54			1.50
B		73			168	82			190	0.81			1.86
A X B		51			126	151			370	1.07			2.42
Control:													
C ₁ : RPP		3322				5281				38.64			
C ₂ : CF		3116				4898				38.87			
		S.Em±			C.D at 5%	S.Em±			C.D at 5%	S.Em±			C.D at 5%
Control vs interactions		62			179	121			350	0.86			2.51

A₁: Natural Farming, A₂: Organic Farming, A₃: Intensification of natural farming with required organic farming practices, C₁: Recommended Package of Practices, C₂: Chemical farming Means followed by the same letters do not differ significantly by DMRT at P=0.05

Table 2. Economics of soybean cultivation as influenced by natural, organic and integrated natural farming practices and foliar application of liquid organic manures

Treatment:		Economics (pooled data)											
→ Farming practices		Gross returns (₹ ha ⁻¹)				Net returns (₹ ha ⁻¹)				B:C ratio			
↓ LOM's		A ₁ : NF	A ₂ : OF	A ₃ : INF	Mean	A ₁ : NF	A ₂ : OF	A ₃ : INF	Mean	A ₁ : NF	A ₂ : OF	A ₃ : INF	Mean
B ₁ : Vermiwash @ 10%		123213 ^h	148485 ^c	132964 ^e	134887 ^c	86554 ^{cd}	65666 ⁱ	68217 ^{hi}	73479 ^c	3.36 ^d	1.79 ^{ij}	2.05 ^h	2.40 ^c
B ₂ : Panchagavya @ 5%		145686 ^{cd}	165479 ^a	154366 ^b	155177 ^a	108931 ^a	82752 ^{dc}	89711 ^c	93798 ^a	3.96 ^a	2.00 ^h	2.39 ^f	2.78 ^a
B ₃ : Jeevamrutha @ 20%		126839 ^h	148995 ^c	141710 ^{dc}	139181 ^c	90312 ^c	66496 ⁱ	77283 ^{fg}	78030 ^c	3.47 ^c	1.81 ^{ij}	2.20 ^g	2.49 ^c
B ₄ : Cow urine @ 10%		136246 ^{fg}	155141 ^b	144328 ^{c-c}	145238 ^b	99778 ^b	72702 ^{gh}	79960 ^{ef}	84147 ^b	3.74 ^b	1.88 ⁱ	2.24 ^g	2.62 ^b
B ₅ : Water spray (control)		116310 ⁱ	139999 ^{ef}	111862 ⁱ	122723 ^d	79882 ^{ef}	57600 ^j	48334 ^k	61939 ^d	3.19 ^c	1.70 ^j	1.76 ^j	2.22 ^d
Mean		129659 ^e	151620 ^a	137046 ^b		93091 ^a	69043 ^b	72701 ^b		3.54 ^a	1.84 ^c	2.13 ^b	
Sources of variation		S.Em±			C.D at 5%	S.Em±			C.D at 5%	S.Em±			C.D at 5%
A		1856			5153	1856			5153	0.03			0.09
B		2222			5124	2222			5124	0.04			0.10
A X B		2356			5679	2356			5679	0.05			0.12
Control:													
C ₁ : RPP		169117				130220				4.35			
C ₂ : CF		158584				129491				5.45			
		S.Em±			C.D at 5%	S.Em±			C.D at 5%	S.Em±			C.D at 5%
Control vs interactions		2474			7127	2474			7127	0.06			0.18

Economics (Gross returns, net returns & B:C ratio)

Significantly, higher gross returns (GR) were registered with organic farming practices than NF and INF. Natural farming (NF) and integrated natural farming (INF) practices recorded 14.5 & 9.6% lesser GR, respectively than compared to organic farming (OF) and 23.3 & 18.9% less compared to recommended package of practices (RPP). This shows that the yield can be

increased to the extent of 4.4% Among the foliar sprays significantly higher returns were with panchagavya application and registered 13.3, 10.3, 6.4 and 20.9% higher than vermiwash, jeevamrutha, cow urine and water spray applications, respectively. Among the interactions, Organic farming with panchagavya (A₂B₂) recorded higher gross returns ₹ 165479 per ha and it was higher than RPP and CF by 30.2 and 4.0 %,

respectively. Organic farming with *panchagavya* application resulted in higher gross returns due to the higher seed yield.

Notably, higher net returns were with natural farming practices. Natural farming and integrated natural farming registered 34.8 and 5.3%, respectively higher net returns when compared to organic farming and 28.1 and 21.8% lesser net returns compared to recommended package of practices (RPP). Among the foliar sprays, vermiwash @ 10%, *jeevamrutha* @ 20%, cow urine @10% and water spray applications registered 21.7, 16.8, 10.3 and 33.9%, respectively lower than *panchagavya* @ 5% application. Among the interactions, Natural farming with *panchagavya* (A₂B₂) recorded higher gross returns ₹ 108931 per ha and it was 36.4% lower than RPP and 14.1% higher than CF. Natural farming recorded higher net returns due to less cost involved for the purchase of inputs. Organic farming registered less net returns because of cost involved in the purchase of organic inputs *viz.*, FYM and vermicompost (70 to 75% of total cost of cultivation). Similarly, less net returns in integrated natural farming in which 50 % of the organic inputs applied in the organic farming.

B: C ratio was higher with RPP and followed by CF, NF, INF and OF. A higher B: C ratio was reported by natural farming

with *panchagavya* (A₁B₂) (3.96). Higher net returns in RPP was due to higher seed and halum yields leads to higher net returns and ultimately reflected in B:C ratio than other treatments. Whereas, B: C ratio was higher in NF with *panchagavya* this was due to less cost incurred in cultivation.

During the investigation, it was found that, the stable yields of seed and halum and higher nutrient uptake were observed with organic farming with *panchagavya* @ 5% foliar application in soybean. It was on par with recommended package of practices. In terms of B: C ratio natural farming treatment combinations gave higher values.

Conclusions

The findings were soybean productivity, nutrient uptake and economics are markedly influenced by different farming practices and foliar application of liquid organic manures. The recommended package of practices (RPP) recorded superior yield and profitability. However, organic farming combined with *panchagavya* @ 5% produced on par results with RPP. Natural farming with foliar application of liquid organic manures yielded lower values of yield but benefit-cost ratio was high due to reduced cost of cultivation.

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