Indian Journal of Traditional Knowledge
Vol 23(8), August 2024, pp 771-779
DOI: 10.56042/ijtk.v23i8.2914

Comparison of natural farming with organic and conventional farming practices in green gram-paddy cropping system

Siddu Malakannavar*, M A Ananthakumar, M T Sanjay, K S Divyashree, M C Nagaraju, C Bindushree & M N Shivakumar

Natural Farming Project, ZARS, VC Farm, Mandya, University of Agricultural Sciences, GKVK, Bengaluru 560 065
*E-mail: msidduagri24@gmail.com

Received 19 June 2023; revised 28 February 2024; accepted 29 July 2024

Natural farming system (NFS) is one of the traditional cultivation methods to cut down production costs as well as dependence on external inputs. Being considered as an agro-ecologically diverse farming practice, it brings a host of ecological and social benefits. In order to know the sustainance of natural farming practice, field experiments were conducted at Zonal Agriculture Research Station (ZARS), V.C. Farm, Mandya, Karnataka, India for consecutive years (2019 to 2022). The experiments were laid out in a randomized complete block design comprised of five replication and four different farming practices as treatments namely, absolute control (AC), organic production system (OPS), Natural farming system (NFS) and recommended package of practice (RPP) of UAS, GKVK, Bengaluru. The pooled data of farming practices indicated significant variation in growth, yield and nutrient uptake, among farming practices significantly higher growth, yield and nutrient uptake were recorded with RPP both in green gram and paddy. The results of four years pooled data indicated that compared to conventional farming practice, natural farming recorded decreased yield of 134 (23.53%) and 3350 kg ha^{-1} (74.49%) in green gram and paddy, respectively. Also recorded 33.38% and 30.23% weed control efficiency by mulching in green gram and paddy, respectively. Based on this study we found that low nutrient demanding crops such as green gram (Pulses) are more suitable under natural farming compared high nutrient demanding crops *viz.,* Paddy. Yields under natural farming can be enhanced by application of Farm yard manure and other natural sources for plant nutrition.

Keywords: Green gram, Natural farming, Nutrient balance sheet, Paddy, Weed control efficiency

IPC Code: Int Cl.[24]: A01G 22/22, A01G 22/40, A01M 21/00

In India, food grains occupy 65% of total gross cropped area comprising cereals and pulses in about 50% and 14%, respectively. India is the largest producer, importer and consumer of pulses. The demand–supply gap is expected to grow further if the level of production of pulses in India is not increased. The per capita availability of pulses declined steadily on account of sluggish growth in the production of pulses. To fulfil the growing demand of pulses in the country, dependence on imports is rising[1]. Presently it covers an area 28.78 million ha of pulse with the annual production of 25.46 million tonnes and an average productivity of 885 kg/ha[2]. Among the grain legumes, green gram [*Vigna radiata* (L.)], commonly known as mung bean is an excellent source of high-quality protein. It contains about 25% protein with high digestibility[3]. Green gram covers an area of 34.80 lakh ha with 3.15 million tonnes production in the year of 2021-22[4]. There is a substantial scope of summer green gram cultivation in marginal lands. Besides having vital aspects like, very little or no infestation of insect pest and disease, short duration, improves the soil health and fertility due to addition of organic matter and about 30-50 kg ha^{-1} nitrogenfixation[5].

Rice (*Oryza sativa* L.) is one of the most important food crops in the world and staple food for more than 50% of the global population. Being the major source of food after wheat, it meets 43% of calorie requirement of more than two third of the Indian population. In India, it is grown in an area of about 46 m ha with a total production of 125 m t and productivity of 4.08 t/ha[6]. Direct seeded rice (DSR) is the viable option for mitigating soil degradation with scientific based water management. DSR refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery. Direct seeding offers certain advantages like saving irrigation water, labour, energy, time, reduces

*Corresponding author

emission of greenhouse-gases, better growth of succeeding crops, etc. The share of water for agriculture is declining very fast because of the increasing population, lowering of the water table, declining water quality, inefficient irrigation systems and competition with non-agricultural sectors. In Asia, the share of water in agriculture declined from 98% in 1900 to 80% in 2000, and it further decline to 72% by 2020[7]. Hence direct seeded rice is viable option where it demands less water than transplanted paddy.

Cropping system has attained substantial significance in intensified agriculture in world as well as in India, to overcome the drawbacks of single cropping system to exploit the soil intensively for enhanced food production. Cultivation of rabi urdbean and mungbean in coastal regions of South India is being practiced since long but it could get momentum and expanded only after development of powdery mildew resistant genotypes such as LBG 17, LBG 402, LBG 611 and LBG 22 having high yield potential. Development of these varieties in late eighties has revolutionized urdbean and mungbean cultivation in rice fallow especially in Andhra Pradesh. This system is highly productive and stable besides its benefits through improvement in soil health. This cropping system is now being practiced in other states like Odisha, Tamil Nadu and Karnataka[8].

Conventional farming uses synthetic chemicals where they cause severe effects on the natural environment such as increased greenhouse gas emissions, soil erosion, water pollution, and threatens human and other animal health. Whereas, organic farming avoids these synthetic chemicals and causes minimum effect on environment but it depends on huge bulky organic manure where it is difficult to meet manures requirement to all the farmers and it depends on external inputs which makes burden to small farmers to invest more, however natural farming is best solution for this where it has overcome the problems of conventional and organic farming. In India most of paddy and green gram area under conventional farming, paddy alone receives 18% pesticide[9] and 37% fertilizer[10].

Natural farming is a system developed in the 1980s by Indian farmer, agricultural scientist and extension personnel Subhash Palekar who established Natural farming system (NFS) after a period of self-study of the Vedas (the oldest of the Hindu scriptures), organic farming and conventional agricultural science, testing methods on his farm and named as zero budget natural farming. The phrase 'zero budget' refers to the aim of achieving dramatic cuts in production costs by ending dependence on external synthetic inputs and agricultural credit. It is not meant to signify 'zero costs'. Instead, as practicing farmers clarify, it is meant to signify that 'the need for external financing is zero and that any costs incurred can be offset by a diversified source of income'[11]. In this method soil is supplemented with the microbial consortium like Beejamrutha and Jeevamrutha to accelerate the proliferation of soil micro flora which is beneficial to soil organic matter enrichment. The philosophy of the natural farming is to nurture the growth of beneficial microorganisms without using external manure and chemical pesticides. Soil microorganisms play a major role in improving soil fertility, as they involve in the recycling of nutrients like carbon and nitrogen, which are required for plant growth[12]. Consortium of beneficial micro-organisms in jeevamrutha converts the nutrients which are in immobilised form into dissolved form, when it is inoculated to the soil. Jeevamrutha is either sprayed or sprinkled on the crop field. In addition to these, farmers reduce or avoid the application of synthetic pesticides, relying instead on traditional preparations neemastra and brahmastra etc., for controlling fungus and insect pests, sourced from locally available trees and plants such as neem, chili, garlic and tobacco[13]. Natural farming has so far been adopted most prominently in the states of Maharashtra, Himachal Pradesh, Andhra Pradesh and in Karnataka. Adoption in Karnataka has been achieved through a grassroots social movement, initially spearheaded in 2002 by the Karnataka Rajya Raitha Sangha[14]. However, the information on use of beejamrutha, jeevamrutha and ghanjeevamrutha for production of green gram and rice is meagre and there are no scientific evidences on natural farming which is proposed by Subhash Palekar. So, in order to validate the natural farming the present investigation was carried out and this paper reports the response of green gram-rice to natural farming in comparison with other farming practices.

Materials and Methods

Experimental site

The experiment was under taken with a view of comparing natural farming with other farming practice in green gram and Paddy (direct seeded rice) at G block, ZARS, VC farm, Mandya which come under southern dry zone of Karnataka (India).

Geographically the centre is placed between 12’45’ to 13’57’ North latitude and 76’45’ to 78’24’ East longitude and it is at an altitude of 695 m above MSL. The centre received 986 mm mean annual rainfall in 54 rainy days and is unevenly distributed. Hence, crop was fully raised under external irrigation from Krishna Raja Sagar Dam. The experiments were under taken during summer (Green gram) and kharif (Paddy) of 2019, 2020, 2021 and 2022.

Soil physical and chemical properties

The soil at the experimental site was sandy loam with neutral pH (7.4), normal electrical conductivity (0.12 dS m^{-1}), low organic carbon (4.9 g kg^{-1}), medium available nitrogen (340.03 kg ha^{-1}), medium phosphorus (35.18 kg ha^{-1}) and low potassium content (165.17 kg ha^{-1}) and details of protocol mentioned in Table 1.

Experimental details

The experiment comprising of four treatments and laid out in a randomized block design with five replications using KKM-3 of green gram in summer and KMP-1001 of paddy in *kharif* were sown at the spacing of 30 cm × 10 cm. Area of gross and net plot was 108 m^2 (9 m × 12 m) and 87.36 m^2 (7.8 m × 11.2 m), respectively. The treatments comprised of T_1: Absolute control (AC); T_2: Organic production system (OPS); T_3: Natural Farming system-protocol as given by Shri. Subhash Palekar (NFS); T_4: Recommended package of practices, UAS, GKVK, Bengaluru (RPP). Details of each treatment are mentioned in Table 2.

The major four principles of ZBNF are,

(1) Beejamrutha: A solution of concoction prepared from locally available natural resources for the purpose of treatment for seeds, seedlings or any planting material. It reduces the possibility of seed infestation by pests and protects young roots from fungus, soil-borne diseases and seed-borne diseases. The ingredient includes, dung and urine from the indigenous breed cow and act as a powerful fungicide and anti-bacterial agent, respectively.

(2) Jeevamrutha: Fermented microbial culture prepared from locally available natural resources for the purpose of being applied to the soils/plants at different stages of their growth. It is a form of bio-fertilizer, a catalytic agent, promoting microorganism and earthworm activity in the soil. The fermentation process (48 h) multiplies aerobic and anaerobic bacteria present in the cow dung and urine, as they utilize organic ingredients and a handful of undisturbed soil acts as inoculate of native species of microbes and organisms. Its application acts as a preventive measure against fungal and bacterial diseases. It can be applied through irrigation water or through foliar spray.

(3) Acchadana/Mulching: It conserves soil and water, facilitates aeration and promotes water retention.

Table 1 — Standard protocol used for soil physico-chemical properties analysis

	Particulars	Method Used
1	Mechanical composition	International pipette method[15]
2	pH (1:2, soil: water)	pH meter (Jackson, 1973)[16]
3	Electrical conductivity ($dS\ m^{-1}$) (1:2 soil: water)	Conductivity bridge method (Richards, 1954)[17]
4	Organic carbon (%)	Walkley and Black (Jackson, 1973)[16]
5	Available N (kg ha^{-1})	Alkaline permanganate method[18]
6	Available P_2O_5 (kg ha^{-1})	Olsen’s method[19]
7	Available K_2O (kg ha^{-1})	Flame photometric method[17]

Table 2 — Treatment details

Treatments	Green gram	Paddy
T_1	Only sowing of seeds.	Only sowing of seeds.
T_2	FYM applied based on N equivalent (25 kg N ha^{-1}) + mulching with paddy straw (4t ha^{-1}) + weeding at 30 DAS, earthing up at 45 DAS.	FYM applied based on N equivalent (100 kg N ha^{-1}) + mulching with paddy straw (4 t ha^{-1}) + weeding at 30 DAS.
T_3	Ghanajeevamrutha (1000 kg ha^{-1}) + Beejamrutha seed treatment + Jeevamrutha at 15 days interval (500 liters ha^{-1}) + mulching with paddy straw (4t ha^{-1}) at 30 DAS.	Ghanajeevamrutha (1000 kg ha^{-1}) + Beejamrutha seed treatment +Jeevamrutha at 15 days interval (500 liters ha^{-1}) + mulching with paddy straw (4t ha^{-1}) at 30 DAS.
T_4	FYM (7.5 t ha^{-1}) + N: P_2O_5: K_2O (25:50:50 kg ha^{-1}) as basal dose + earthing up at 45 DAS.	FYM application (10 t ha^{-1}) +N: P_2O_5 : K_2O (100:50:50 kg ha^{-1}) recommended dose of nitrogen applied as 50% N and 100% P as basal, Remaining 50% N was applied at tillering & panicle initiation stage at equal splits, potassium was applied as 50% basal + 50% tillering and Spraying of pre-emergence herbicide (bensulfuron methyl 0.6% + pretilachlor 6% GR @ 10 kg /ha) at 2-3 DAS and post emergence herbicide (bispyribac sodium 10% SC @ 200 mL / ha) at 30 DAS and one hand weeding.

a) Biomass mulching: The application of dry organic matter along with Jeevamrutha will improve soil fertility through decomposition and humus formation, and it will also suppress the growth of weeds. b) Live mulching: The inter-cropping or mixed-cropping by combining monocots with dicots, creates a symbiotic relationship because monocots will supply elements like potash, phosphate, and sulphur, while dicots helps in nitrogen-fixation.

(4) Whapasa/Moisture: The natural farming adoption helps to maintain appropriate water and air in the soil or the relevance of soil moisture.

Data collection

Plant growth

Plant height was measured by selecting five random plants from each net plot, tagging the selected plants and recording plant height at monthly intervals from sowing to harvest. For the measurement of plant height, length from the ground surface of plants to the base of the completely opened leaf before the heading stage and after the heading stage was taken up to the top point of the ear head of the main shoot. The number of tillers and leaves was counted randomly tagged five hills at monthly intervals beginning on 30 DAS in paddy similarly number of branches and leaves were count in green gram by randomly tagged five plants.

Yield attributes

At the time of harvest, five tagged random plants were chosen for estimation of pods per plant then counted number of pods in each of five plants later five pods from each plant were selected and counted the number of seeds per pod. In paddy, panicle length was determined from the base of panicle to the tip of panicle from five plants of each treatment. Similarly, panicle weight we measured by taking tagged five panicle from each treatment. Yield was calculated by harvesting net plot plant of each treatment and later converted into hector both in green gram and paddy. From yield, 100 seeds were selected and weighted by each treatment with five replications to measure test weight.

Weed control efficiency

Numbers of weeds were counted from one meter square area by randomly thrown one meter square plate in net plot of each treatment. Weed control efficiency was worked out by using the formula suggested by Mani *et al.* (1973)[20] and expressed in percentage.

$$\text{WCE} = \frac{\text{Weed count from unweeded plot} - \text{Weed count from treatment plot}}{\text{Weed count from unweeded plot}} \times 100$$

Soil chemical studies and Nutrient balance sheet

After harvested of each crop (Green gram-Paddy), soil samples were taken from each net treated plot at a depth of 0- 15 cm to measure soil chemical properties. Following the same protocol as Table 1, these soil samples were dried and examined for pH, EC, OC, available nitrogen, phosphorus and potassium by using suitable reagents used in standard procedures as mentioned in Table 1. Nutrient balance sheet was worked by subtracting initial soil sample N, P_2O_5 and K_2O and final available N, P_2O_5 and K_2O after four years of experimentation.

Statistical analysis

The data collected on different traits was statistically analysed using the standard procedure and the results were tested with F test at five percent level of significance as given by Gomez and Gomez (1984)[21] with help of Opstat software (http://14.139.232.166/opstat). The critical difference was used to compare treatment means.

Results and Discussion

Growth and yield parameters of green gram

The results of four years pooled data revealed that growth parameters of green gram varied significantly (Table 3). Green gram RPP recorded tallest plant (34.85 cm), greater number of branches (5.68 plant^{-1}) and leaves (20.69 plant^{-1}). Contrarily, shortest plant, lesser number of branches and leaves were recorded with AC. Whereas, NFS recorded 30.32 cm of plant height, 5.07 branches and 17.34 leaves per plant. The higher growth parameters in RPP due to supply of readily available nutrient to plant where NFS didn't meet the nutrient requirement as jeevamrutha and ghanajeevamrutha contain lower amount of nutrients. These results are in conformity with the findings of Muwal and Dhaked (2022)[22].

Similarly, significant variation in yield parameters of green gram was observed during 2019, 2020, 2021, 2022 and pooled (Table 4). Pooled data of green gram recommended package of practices (RPP) recorded maximum number of pods per plant (22.11), seeds per pod (12.87) and test weight (4.12 g). Compared to RPP, NFS recorded lesser number of pods per plant, seeds per pod and test weight. Similarly higher seed yield was recorded with RPP during (536 kg ha^{-1}).

Same trend was followed during four years of experimentation. Higher source area *viz.,* number of leaves and number of branches that resulted higher sink *viz.,* number of pods and seeds in RPP. Similarly, Anon. (2023)[23] Bhargavi *et al.* (2021)[24] reported that RPP recorded higher yield than beejamrutha, jeevamrutha, ghanajeevamrutha and combination of all.

Growth and yield parameters of paddy

Paddy growth parameters *viz.,* plant height, tillers and leaves were observed significantly higher under RPP in pooled (102.80 cm, 15.86 hill^{-1}, 67.62 hill^{-1}, respectively) whereas, AC registered lower growth parameters (Table 5). Growth parameters of NFS were significantly underperformed than RPP whereas, it recorded 55.13 cm plant height, 3.15 tillers per hill and 15.71 leaves per hill. Paddy is nutrient exhaustive crop where the nutrient demand was met by RPP which resulted better growth compared to other farming systems. Similar results were reported by Anisuzzaman *et al.,* (2021)[25].

As like growth parameters, yield attributing characters *viz.,* panicle length, panicle weight and test weight were found superior in RPP (20.00 cm, 2.57 g and 20.23 g, respectively) over OPS, NFS and AC (Table 6). Similar trend was followed during four years of experimentation. Higher yield parameters were due to higher growth parameters which increases the photosynthetic area of plant and also makes better utilization of solar radiation. Even lower weed competition for water, nutrients, space and solar energy in RPP makes better outperformed compared to NFS. These studies are in line with Veeranna *et al.,* (2023)[26] and

Table 3 — Growth attributes as influenced by different farming practices in green gram at harvest

At harvest	Plant height (cm) Mean					No. of branches per plant Mean					No. of leaves per plant Mean				
	2019	2020	2021	2022	pooled	2019	2020	2021	2022	pooled	2019	2020	2021	2022	pooled
AC	26.20	26.06	23.64	22.92	24.71	3.42	4.84	4.12	3.94	4.08	15.20	15.12	13.24	13.21	14.19
OPS	33.60	34.22	27.98	34.82	32.66	5.26	5.66	5.48	5.51	5.48	18.90	17.44	18.06	21.58	18.99
NFS	31.40	30.06	26.18	33.63	30.32	4.96	5.24	4.80	5.29	5.07	18.54	16.90	14.80	19.13	17.34
RPP	35.60	36.36	29.08	38.34	34.85	5.44	5.78	5.60	5.88	5.68	21.16	17.62	19.04	24.93	20.69
S. Em. ±	1.50	1.10	0.70	0.92	0.50	0.20	0.09	0.20	0.42	0.16	1.00	0.30	0.70	0.51	0.38
C.D. (p=0.05)	4.70	3.40	2.20	2.71	1.48	0.80	0.20	0.60	1.24	0.46	3.10	0.90	2.10	1.51	1.12

AC: Absolute control OPS: Organic production system NFS: Natural Farming system RPP: Recommended package of practices

Table 4 — Yield and yield attributes as influenced by different farming practices in green gram

	No. pods per plant Mean					No. of seeds per pod Mean					Test weight (g) Mean				
	2019	2020	2021	2022	pooled	2019	2020	2021	2022	pooled	2019	2020	2021	2022	pooled
AC	15.80	13.56	9.40	9.55	12.05	9.44	10.10	10.44	9.86	9.96	3.16	3.65	3.93	3.68	3.60
OPS	21.20	20.04	19.84	22.33	20.85	11.38	12.90	12.28	13.36	12.48	3.86	4.11	4.00	4.16	4.04
NFS	20.80	16.06	14.22	16.66	16.94	10.52	11.62	11.88	12.22	11.56	3.78	3.82	3.92	3.95	3.87
RPP	21.80	22.44	20.84	23.35	22.11	11.66	13.20	12.96	13.65	12.87	3.90	4.26	4.03	4.29	4.12
S.Em. ±	1.00	0.80	1.00	0.20	0.41	0.50	0.35	0.30	0.42	0.22	0.05	0.04	0.06	0.09	0.04
C.D. (p=0.05)	3.30	2.40	3.10	0.59	1.20	1.50	1.06	1.10	1.25	0.63	0.10	0.10	NS	0.27	0.12

AC: Absolute control OPS: Organic production system NFS: Natural Farming system RPP: Recommended package of practices

Table 5 — Growth attributes as influenced by different farming practices in paddy at harvest

At harvest	Plant height (cm) Mean					No. of tillers/ hill Mean					No. of leaves/ hill Mean				
	2019	2020	2021	2022	pooled	2019	2020	2021	2022	pooled	2019	2020	2021	2022	pooled
AC	38.82	31.86	46.20	48.48	41.34	3.50	1.82	1.60	2.66	2.40	15.08	7.94	12.10	11.85	11.74
OPS	69.16	78.86	82.25	78.96	77.31	7.34	7.36	7.80	7.08	7.39	30.58	39.20	25.30	31.47	31.64
NFS	55.32	39.64	57.20	68.35	55.13	4.20	2.36	2.30	3.73	3.15	22.56	10.06	11.24	18.98	15.71
RPP	85.56	104.26	110.37	111.01	102.80	15.48	15.60	16.40	15.97	15.86	52.18	78.50	69.97	69.83	67.62
S.Em. ±	1.93	1.12	1.33	2.27	0.80	0.45	0.20	0.1	0.31	0.17	2.15	0.90	0.81	1.85	0.88
C.D. (p=0.05)	5.88	3.40	3.98	6.68	2.35	1.35	0.59	0.5	0.92	0.50	6.45	2.71	2.43	5.46	2.60

AC: Absolute control OPS: Organic production system NFS: Natural Farming system RPP: Recommended package of practices

Salam *et al.,* (2020)[27] they reported that chemical weed management and hand weeding performed better than no weeding.

Influence of different farming practice on WCE

In the present study, different farming system has different way of weed management practice, whereas in NFS weed growth is mainly suppressed by mulching. Result of the four-year experimentation shows higher WCE with green gram RPP at 60 DAS (74.68%) followed by OPS (65.73%). Least WCE recorded with NFS, this showed mulching alone can suppress weed growth up to 33.38% (Fig. 1a). Similarly, paddy RPP noticed higher weed control efficiency (86.35%) followed by OPS (64.14). Mulching in paddy NFS supress the weed growth up to 30.23% (Fig. 1b). Higher WCE in RPP is due integrated weed management approach by chemical and physical method of control weeds which is quick and effective. Similar results were reported by Kashyap *et al.,* (2022)[28].

Among the crops, higher WCE in NFS was noticed with green gram compared to direct seed rice because it grows faster and cover the surface which causes weed smothering effect whereas, rice grow slowly at initial stage. Similarly, results were reported by Adarsh *et al.,* (2019)[29] who reported that weed smothering efficiency of pulses is higher than cereals.

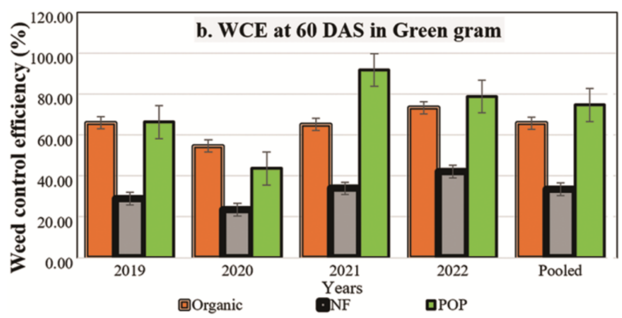

Fig. 1a — Weed control efficiency by different farming practice in green gram

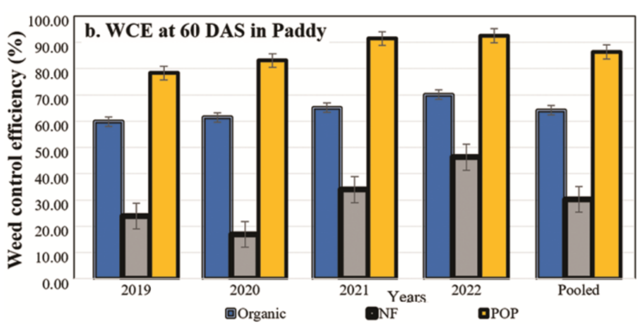

Fig. 1b — Weed control efficiency by different farming practice in paddy

Influence of different farming practice on Nutrient uptake and balance sheet

The nutrient uptake by crop is a function of the nutrient concentration in plant and the dry matter accumulation per unit area. The nutrient uptake by crop had influenced significantly by the production systems (Fig. 2). Among the production systems in green gram, organic farming system (OFS) and natural farming system (NFS) recorded 15.5, 11.3 & 13.1; 34.1, 30.3 & 29.8% lower uptake of nitrogen, phosphorus and potassium respectively as compared to RPP. Similar trend was also noticed in paddy. However, paddy is nutrient exhaustive crop where it

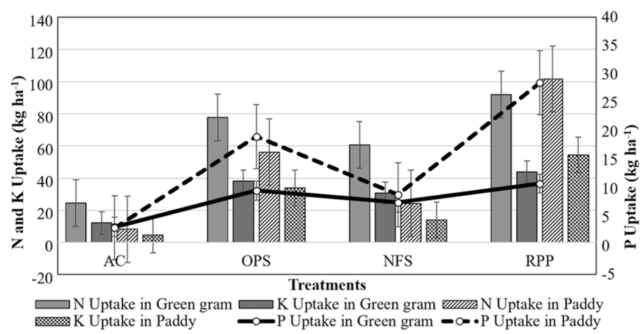

Fig. 2 — Nutrient uptake as influenced by different farming practices in green gram-paddy cropping system (Pooled data)

Table 6 — Yield and yield attributes as influenced by different farming practices in paddy

	Panicle length (cm) Mean					Panicle weight (g) Mean					Test weight (g) Mean				
	2019	2020	2021	2022	pooled	2019	2020	2021	2022	pooled	2019	2020	2021	2022	pooled
AC	9.48	10.56	10.50	7.44	9.50	0.70	0.53	0.64	0.70	0.64	17.0	15.6	17.2	14.29	16.03
OPS	17.02	18.29	17.20	15.12	16.91	2.23	2.47	1.60	1.67	1.99	18.6	17.4	18.7	17.69	18.09
NFS	15.62	13.50	14.80	16.12	15.01	1.35	0.85	1.70	1.79	1.42	17.8	16.6	16.8	17.04	16.97
RPP	19.00	22.09	21.16	18.74	20.00	2.59	3.44	2.07	2.19	2.57	19.0	18.7	22.9	20.29	20.23
S.Em. ±	0.4	0.1	0.37	0.45	0.20	0.15	0.04	0.04	0.04	0.04	0.06	0.10	0.4	0.96	0.29
C.D. (P=0.05)	1.2	0.42	1.11	1.33	0.59	0.45	0.13	0.11	0.13	0.11	0.2	0.3	1.1	2.83	0.85

AC: Absolute control OPS: Organic production system NFS: Natural Farming system RPP: Recommended package of practices recorded higher uptake of nutrients than the green gram. The readily available nutrient in soil through inorganic farming systems enhances the uptake of nutrients by the crops. The recommended dose of fertilizer with FYM was attributed to ready availability of nutrients and also balanced nutrition enhanced the synergistic effect on uptake of other plant nutrients[30]. While in organic and natural farming system depending on decomposition and mineralization of manures delay the availability of nutrients, might be the probable reasons for lower uptake of nutrients as compared to inorganic farming system.

The nutrient balance sheet was worked out under various farming system by growing legume – cereal cropping system after 8th crop cycle (Fig. 3). In the present study, the available nitrogen was depleted due to various loss *viz.,* leaching, volatilization, denitrification and microbial fixation in addition to crop demand. The loss of available nitrogen was more in NFS compared to OFS and INS due to less supplementation of high required nitrogen. The phosphorus content was gained in all the farming systems, the increased microbial activity and microbial population in manure treated plots (OFS & NFS) were responsible for solubilisation of native inorganic phosphate. While the potassium was increased due to mulching of paddy straw and also K bearing minerals *viz.,* orthoclase feldspar and mica undergoes mineralization and decomposition by enhanced microbial activity. The results clearly indicated that irrespective of farming system, there is need of supplementing nitrogen rich manures/ fertilizers which are resistant to various losses to maintain optimum soil fertility and also fulfil the crop demand.

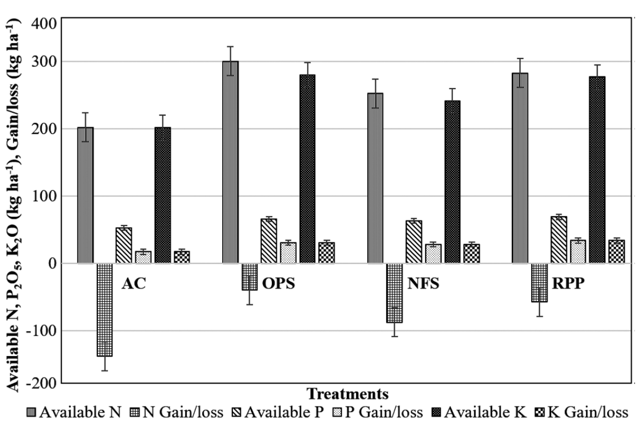

Fig. 3 — Nutrient balance sheet as influenced by different farming practices in green gram-paddy cropping system

Comparison of pulse and cereal performance in the Natural farming

Generally, crops required essential nutrients to complete their life cycle; nitrogen, phosphorus and potassium in large quantity, if deficiencies of these nutrients causes major effect on growth and development of the crop. Performance of the crop is good when it has minimum competition for natural resources such as space, water, nutrients and solar energy.

Results of Figure 4 revealed that RPP registered higher yield over NFS during four years of experimentation and pooled data. Green gram NFS recorded 1.84, 38.48, 35.28, 15.44 and 18.76% decrease in yield over RPP in the year 2019, 2020, 2021, 2022 and pooled, respectively. Similarly, paddy in the NFS recorded 55.62, 79.30, 80.39, 71.97 and 74.49 per decrease in yield over RPP in the year 2019, 2020, 2021, 2022 and pooled, respectively. Over the years yield gap between RPP and NFS was wider in paddy because of higher nutrient mining by paddy followed by lower supplement of nutrients through jeevamrutha and ghanajevamrutha along with higher weed competition. However green gram performs better than paddy as gap between RPP and NFS is lesser and over the years showed decreasing trend. This is because green gram is less nutrient demand crop, ability to fix atmospheric nitrogen and covers ground quickly causes weed smothering effect. Nutrient supplementation and weed competition are major limitations for the growth and productivity of paddy and green gram in natural farming. The inclusion of two to three hand weeding sessions and supplementation with locally available manures, such

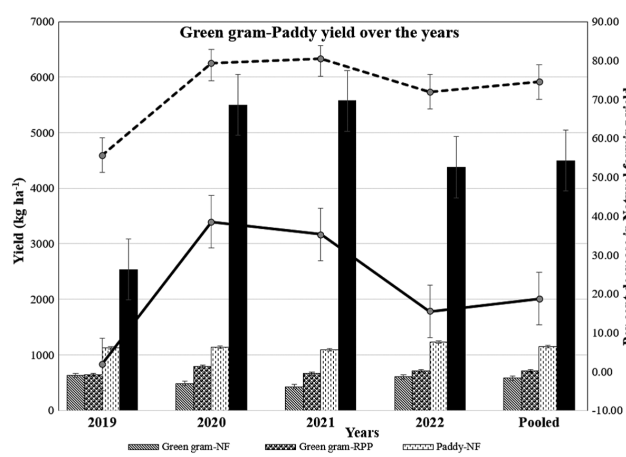

Fig. 4 — Influence of natural farming and recommended package of practice on yield of green gram-paddy and per cent decrease in the natural farming yield over recommended package

as farmyard manure and crop compost etc, can enhance the yield potential of natural farming to the level of conventional practices.

Conclusion

Among the farming practices, conventional farming followed by organic farming recorded significantly higher growth, yield and weed controlling index compared to natural farming practice. In natural farming, percent reduction in yield of green gram is lesser than paddy when compared to conventional practice because green gram requires lesser nutrition, ability to fix atmospheric nitrogen and weed smothering effect. The practice of this natural farming system can be adopted in low nutrient demanding crops like green gram and difficult to adopt for high nutrient demanding crops but addition of more nutrients through natural sources such as farm yard manure and other wastes can enhance the productivity of the crops.

Acknowledgments

Karnataka State Department of Agriculture, Bangalore is gratefully acknowledged for providing necessary funding for execution of this study.

Conflict of Interest

The authors declare that there is no conflict of interest.

Author Contributions

The study was conducted under the guidance of SM and the basic idea of the research was given by SMT & AMA verified the analytical methods and research work was carried out by SM. All the authors contributed to the preparation of final manuscript.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

References

1 Ahlawat I P S, Sharma P & Singh U, Production, demand and import of pulses in India, *Indian J Agron,* 61 (2016) S33-S41.
2 Anonymous, Annual report, directorate of pulse development, Bhopal, (2022a) p. 03.
3 Payasi D, Pandey S, Nair S K & Pandey R L, Genetics of biochemical and physiological parameters responsible for powdery mildew disease resistance in mungbean*, J Food Legumes,* 24 (2011) 292-295.
4 Anonymous, *Greengram Outlook, December 2022,* (Directorate of Economics and Statistics, Agricultural Market Intelligence Centre, PJTSAU), (2022) 01-02.
5 Singh G, Ram H, Sekhon H S, Aggarwal N, Kumar M, *et al.,* Effect of nitrogen and phosphorus application on productivity of summer mungbean sown after wheat, *J Food Legumes,* 24 (2011) 327-329.
6 Anonymous, *Grain and feed annual-2022*, India, (United states department of agriculture), (2022b) p. 02.
7 Kumar V & Ladha J K, Direct seeding of rice: recent developments and future research needs, *Adv Agron,* 111 (2011) 297-413. *https://doi.org/10.1016/B978-0-12-387689-8.00001-1*.
8 Singh K K, Ali M & Venkatesh M S, *Pulses in Cropping Systems, Technical Bulletin,* (Indian Institute of Pulse Research, Kanpur), (2009), p. 08. (-*https://iipr.icar.gov.in/wp-content/themes/ICAR-wp/images/pdf/pulses_in_cropping_systems.pdf*.-)
9 Indira Devi P, Thomas J & Raju R K, Pesticide consumption in India: A spatiotemporal analysis, *Agric Econ Res Review*, 30 (1) (2017) 163-172. DOI: 10.5958/0974-0279.2017.00015.5.
10 Usama M & Khalid M A, Fertilizer consumption in India and need for its balanced use: A review, *Indian J Environ Prot*, 38 (7) (2018) 564-577.
11 Khadse A & Rosset P M, Zero budget natural farming in India – from inception to institutionalization, *Agroecol Sustain Food Syst,* 43 (7-8) (2019) 848-871. DOI: 10.1080/21683565.2019.1608349.
12 Lazarovits G, Rhizobacteria for improvement of plant growth and establishment, *Hortic Sci,* 32 (2) (1997) 188-192. DOI: 10.21273/HORTSCI.32.2.188.
13 Anusha L, Effect of liquid organic manure *'Jeevamrit'* on the productivity of wheat under zero budget natural farming system. M.Sc., thesis, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur, 2018.
14 Khadse A, Rosset P M, Morales H M & Ferguson B G, Taking agroecology to scale: the Zero Budget Natural Farming peasant movement in Karnataka, India, *J Peasant Stud*, 45 (1) (2017) 192-219. http://dx.doi.org/10.1080/03066150.2016.1276450.
15 Piper C S, *Soil and Plant Analysis*, (Hans Publishers, Bombay), 1966.
16 Jackson M L, *Soil chemical analysis*, (Prentice Hall of India Pvt. Ltd. New Delhi), (1973) 468.
17 Richards L A, *Diagnosis and improvement of saline and alkali soils,* USDA, The United States Salinity Laboratory Staff, Hand Book No. 60 (1954).
18 Subbiah B C & Asija G L, A rapid procedure for the estimation of available nitrogen in soils, *Curr Sci,* 25 (1956) 259-60.
19 Olsen S R, Cole C V, Watanable F S & Dean L A, *Estimation of available phosphorous in soil extraction with sodium bicarbonate,* (USDA Circular), (1954) 939.
20 Mani V S, Malla M L, Gautam K C & Bhagwndas, Weed killing chemicals in potato cultivation, *Indian Farming,* 22 (1973) 17-18.
21 Gomez K A & Gomez A A, *Statistical Procedures for Agricultural Research-: An* International Rice Research Institute Book, (A Willey – Interscience Publication, John wiley and sons Inc, New York, United states of America), 1984.
22 Muwal S R & Dhaked G S, Effect of organic manure and inorganic fertilizer on growth, yield and quality of green gram (*Vigna radiata* L.), *Int J Creat Res Thoughts,* 10 (8) (2022) 770-787.
23 Anonymous, Research highlights of the "natural farming project" at UAS, Dharwad of Karnataka (Zone -08 (Agri), Highlights of "Natural Farming Research in Different

Agro climatic Zones of Karnataka" State level workshop on natural farming (NF), (2023) p. 46.

24 Bhargavi Y, Sudhakar P, Rajeswari V R & Krishna T G, A comparative assessment of fertilizers and natural organics on yield and seed quality attributes of blackgram, *Int J Curr Microbiol Applied Sci,* 10 (5) (2021) 306-315. *https://doi.org/10.20546/ijcmas.2021.1005.038.*

25 Anisuzzaman M, Rafii M Y, Jaafar N M, Ramlee S I, Ikbal M F, *et al,* Effect of organic and inorganic fertilizer on the growth and yield components of traditional and improved rice (*Oryza sativa* L.) genotypes in Malaysia, *Agronomy,* 11 (2021) 1830. *https://doi.org/10.3390/agronomy11091830.*

26 Veeranna H K, Balaji Naik D, Shilpa M E, Shilpa H D & Adarsha S K, Comparative evaluation of natural farming systems for enhancing crop productivity and income of farmer to improve livelihood security of farm families in southern transition zone (Zone - 7) of Karnataka, *Highlights of "Natural Farming Research in Different Agro climatic Zones of Karnataka" State level workshop on natural farming* (*NF*)*,* (2023) 40-41.

27 Salam M A, Sarker S & Sultana A, Effect of weed management on the growth and yield performances of boro rice cultivars, *J Agric Food and Environ,* 4 (1) (2020) 19-26. *http://doi.org/10.47440/JAFE.2020.1404.*

28 Kashyap S, Singh V P, Guru S K, Pratap Tej, Singh S P, *et al*, Effect of integrated weed management on weed and yield of direct seeded rice, *Indian J Agric Res,* 55 (1) (2022) 33-37. DOI:10.18805/IJARe.A-5775.

29 Adarsh S, John J & Thomas G, Role of pulses in cropping systems: A review, *Agric Rev,* 40 (3) (2019)185-191. DOI:10.18805/ag.R-1888.

30 Mondal S, Mallikarjun M, Ghosh M, Ghosh D C & Timsina J, Influence of integrated nutrient management (INM) on nutrient use efficiency, soil fertility and productivity of hybrid rice, *Arch of Agron Soil Sci,* 62 (11) (2016) 1521-1529. DOI: 10.1080/03650340.2016.1148808.