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EFFECT OF GOOD AGRICULTURAL PRACTICES (GAP) WITH SOIL AMENDMENT ON PRODUCTION POTENTIAL OF OKRA (*Abelmoschus esculentus* L.) IN NEW ALLUVIAL ZONE UNDER WEST BENGAL

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ABSTRACT

A field experiment was carried out to evaluate the effect of Good Agricultural Practices (GAP) with soil amendment on production potential of Okra (*Abelmoschus esculentus* L.) and the effect of GAP was compared with farmers, conventional method (CM). This practice emphasises on soil test based Integrated Nutrient Management (INM) with replacement of chemical fertilizers by Bio-fertilizers and Integrated Pest Management. The experiment was conducted for three successive years (2017, 2018 and 2019) in 13 fields in randomised block design. Soil organic carbon content (from 0.29% to 77%), soil nitrogen content (from 178.85 kg ha^{-1} to 332.15 kg ha^{-1}), soil P_2O_5 content (from 64.08 kg ha^{-1} to 92.46 kg ha^{-1}) and soil K_2O content (from 90.77 kg ha^{-1} to 121.15 kg ha^{-1}) were significantly increased. Population density of some soil beneficial microbes like, *Azotobacter* (from 1.96 x 10^5 cfu to 6.50 x10^5 cfu g^{-1} of soil), Phosphate Solubilizing Bacteria (from 1.72 x 10^5 cfu g^{-1} soil to 4.08 x10^5 cfu g^{-1} soil) and potash solubilizing bacteria (from 2.48 x10^5 cfu g^{-1} soil to 4.56 x10^5 cfu g^{-1} soil) were also increased after three year GAP implementation, yield and yield contributing parameters were significantly enhanced by GAP over CM, i.e. plant height(81.46 to 88.97 cm), green pod weight (22.32 to 26.31 g), pod length(14.80 to 16.09 cm), number of pods plant $^{-1}$ (30.90 to 33.85), yield plant^{-1} (688.45 to 887.51 g) and yield ha^{-1} (98.28 to 117.78 q ha^{-1}) . Germination percentage (73.21% to 81.59%), seedling length (from 66.30 mm to 74.00 mm) , vigour Index (from 3195 to 4474), dehydrogenase activity as OD (0.32 to 0.45), green pod protein (1.09% to 1.44%) and seed protein (11.02% to 15.21%) were also increased in GAP as compared to conventional practice (CM).

Key word: (Okra, GAP, soil characters and Crop yield)

INTRODUCTION

Okra is one of the most economical vegetables and it belongs to *Malvaceae* family. It is an essential vegetable in Indian diet. India has the challenging task of feeding a global population of 17.7% (Anonymous, 2021.) with only 4% (Lahiri, 2017) of the water and 2.4% (Kumar, 2011) of the land resources. The key contribution to the production jump in Indian agriculture undoubtedly ensued from the Green Revolution of the mid 1960s through the adoption of high yielding varieties, coupled with the increased use of fertilizers, pesticides and irrigation water. However, this had also posed the challenge of combating the threat of unbalanced fertilization resulting in soil health deterioration. Indeed, the estimates suggest that 120.7 M ha of the land in India is affected by various degrees of soil degradation (Raina *et al.,* 2014). The incidence and dynamics of insect pests on okra are essential to develop a sustainable management practices. Good Agricultural Practices (GAP) enables the plant to respond in better way for the inputs. In fact, GAP ensures economic and social sustainability for on-farm processes and result in safe and quality food and non-food agricultural products. In the era of declining factor productivity and degradation of natural resource base of agricultural production system, there is an urgent need to develop GAP. The transfer of GAP to the farmer's field is the only option to achieve the goal of sustainable use of natural and man-made resources. It is suggested that GAP has the potentiality for long-term agricultural sustainability. The quality outcomes from field in term of input use efficiency and productivity will be led by better understanding of this practice by the farmers. Doubling farmers' incomes is the flagship scheme of Government of India. Under present scenario of numerous resource- and production–vulnerabilities besides climate change, the GAP

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will help to meet these challenges and has great potential in elevating farm income, managing risk of farming, optimizing resource use efficiency and generating agro-based employments. It mostly comprised of two components one is Integrated Nutrient Management another Integrated Pest Management. Good Agricultural Practice involving soil analysis based fertilizer application with special emphasis on organic manure and biofertilizer, 25% replacement of recommended chemical fertilizer with biofertilizer and Integrated Pest Management (IPM) has its positive impact on soil pH, and other soil fertility attributes like nitrogen and organic carbon content of soil. Further evaluation of impact of GAP on quantitative as well as qualitative aspects of farm products is required. As the impact of GAP on soil properties and related to soil fertility, it is expected that this practice may increase and restore productivity of soil.

MATERIALS AND METHODS

The field experiment was conducted for 3 consecutive years (2017-2018-2019) with two treatments **1.** Conventional Method (CM). **2.** Good Agriculture Method (GAP) in 13 replications. The CM refers to farmer's own practice where there is no balanced use of fertilizer and pesticides. Fertilizers and pesticides are used on the basis of farmer's own observation and advice of the fertilizer, pesticides dealers. In GAP, emphasis was given on soil rather than on crops. Integrated Nutrient Management (INM), consisting of determination of soil nutrient content and management of required plant nutrient by organic, biological and chemical resources in a calculative way with 25% replacement of recommended dose of chemical fertilizers by Biofertilizers (*Azotobacter* for nitrogen, Phosphate Solubilizing Bacteria for phosphate and Potash Solubilizing Bacteria for Potash). The fields were previously applied with *Azolla* as green manure during previous *kharif* paddy cultivation. Integrated Pest Management (IPM) practices, consisting of cultural, mechanical, biological and then chemical practices, was followed. The chemical pesticides were applied when pest and disease infestation was beyond the threshold level after practicing the former three practices and the WHO banded pesticides were avoided.

Experimental site

Thirteen fields were selected for study in Ula village of North 24 parganas district of West Bengal. The village having Lat–Long 22.722748, 88.553066, 9 KM from district headquarter, Barasat located in Gangetic alluvial agro climatic zone. The village is of intensive agriculture having cropping intensity 235%.

Determination of soil pH was carried out in soil to water ratio1:2 with help of pH meter, model (Systronics µ pH meter 361) with glass electrode (Jackson, 1967). Electrical conductivity was determined using soil to distilled water ratio (1:2) by EC meter, model (Systronics µ Conductivity meter 306) (Basak, 2000). Organic carbon of soil was estimated by wet oxidation method of Walkley and Black (1934). In available nitrogen determination, the procedure involves distilling the soil with alkaline potassium permanganate solution and determining the ammonia liberated, (Tandon, 1993). For determining plant available P in soil, the method (Olsen, 1954) was followed. Potassium of soil was estimated by Neutral Ammonium Acetate Method (Black, 1965). Microbial count of soil treated and untreated plots were done following dilution plating method and expressed as colony forming unit (c.f.u g^{-1}) of soil. Jensen's Medium was for *Azotobacter* (Jensen, 1942), Pikovskaya's medium for Phosphate Solubilizing bacteria (Pikovskaya, 1948), Aleksandrow's media for Potash Solubilizing Bacteria (Etesami *et al*., 2017).

Yield and some yield attributing parameters, like plant height (cm), green pod weight (g), pod length (cm) and total pod yield for Okra (q) were also recorded. Germination test was done following the inclined glass plate blotter technique described by Punjabi and Basu (1982) with minor modification. The formula as suggested by Abdul-Baki and Anderson (1973) was used to determine seedling vigour index. For studying membrane permeability of treated and untreated seeds, the electrical conductivity of the seed leachate were measured following the method of Anderson *et al.* (1964) with minor modifications. The amount of sugar leached out from the seed was also recorded colorimetrically following the method of Mc Cready *et al*.(1950) with minor modifications. The dehydrogenase enzyme activities of treated and untreated seeds were estimated following the method of Kittock and Law (1968) with minor modifications. Soluble total protein content estimated by Lowry's method (Lowry *et al*., 1951). For biological physical and chemical parameters of soil, base line data were collected prior to trail. The average data for three year the both CM and GAP field were conceder for analysis for yield attributing parameters and seed characters, only average / pooled data 3 years were taken for analysis. The data were analyzed for different characters of okra, all analyzed by using the analysed of variance technique for a RBD as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

The effect of GAP on chemical characters of soil has been given on Table 1. There is no any significant change in all biological , physical and chemical parameters of soil after three years in CM field. Colony forming Unit (cfu x 10^5) increased from 1.96 to 6.50, 1.72 to 4.80 and 2.48 to 4.56 in GAP field for *Azotobacter*, Phosphate Solubilizing Bacteria (PSB), Potash Solubilizing Bacteria (KSB) respectively. Although there is no significant change in EC of soil, a significant change in pH (acidity, 6.17) in CM to normality (6.84) in GAP field was observed. Such impact of GAP was also observed in OC, N, P_2O_5 and K_2O content of soil. Due to GAP, OC increased from 0.29% to 0.77 %. N, (Kg ha^{-1}) P_2O_5, (Kg ha^{-1}) and K_2O (Kg ha^{-1}), content in soil increased from 178.85 to 334.15, 64.08 to 92.46 and 90.77 to 121.15, respectively.

The data regarding yield and yield contributing parameters of okra are given in Table 2. The pooled data clearly showed significant impact of GAP over CM on yield and yield contributing parameters. Yield (q ha^{-1}) was significantly higher in GAP (117.78) as compared to CM (98.28). This is contribution of different yield attributing parameters, like plant height, green pod weight, pod length, number of pod plant $^{-1}$ and yield plant^{-1}, all of which have significant higher value in GAP as compared to CM.

It is noted that higher quality of seed can be produced through GAP (Table 3). Germination percentage was 79.65 in GAP whereas in CM it was 73.21%, there was no significant effect of GAP on EC (dsm^{-1}) and leaching sugar (g ml^{-1}). EC and leaching of sugar were 3.04 and 0.080, respectively in CM, these values were 3.16 and 0.072 respectively in GAP. GAP imparted significant effect on seedling length (mm), vigor index, dehydrogenase activity(OD), green pod protein(%) and seed protein (%) over CM.

As essentially the yield is the final criterion for the evaluation of different treatments, the discussion is therefore, necessarily centered on the effect of treatments on various factors as they finally modified the soil health, yield and seed quality. Efficient and judicious use of all possible resources of plant nutrients is the main aims of Integrated Nutrient Management so as to harvest maximum economic yield reducing the dependency on chemical fertilizers in crop production to certain extent without any harmful effect on soil fertility. The present experiment emphasized on application of organic manures, bio-fertilizers and inclusion of legumes in cropping system (in between paddy and okra) along with balanced use of chemical fertilizers. Good Agricultural Practice (GAP) improved soil properties like organic carbon content considerably. This result corroborated the findings of Kannan *et al.* (2013), who demonstrated that Integrated Nutrient Management in crops using recommended dose of chemical fertilizers and vermi-compost leads to increase in organic carbon content in soil. The better growth in terms of plant height, biomass production and yield in recommended NPK+Vermicompost + biofertilizers (*Azotobacter*, *Rhizobium*, PSB and KSB) treatment could be ascribed to better availability of nutrients. Similarly, Liu *et al.* (2019) demonstrated that soil organic matter and nitrogen promoted growth and activities of soil microbes. Enhancement in level of N, P, K, S, Ca and Mo was reported by continuous application of organic manure (Ginting *et al.,* 2003). Reports are also available where application of organic manure enhances the availability of phosphate (Manna *et al*., 2006) This also results in higher sensitivity to disturbance and lower rates of carbon sequestration, contributing to higher rates of crop damage and a lost opportunity for climate change mitigation. Martinez- Toledo *et al.* (1998) reported that application of a common pesticide, Captan, resulted in decrease in population of nitrogen fixing bacteria and increase in denitrifying bacterial population. In GAP this pesticide is avoided and nitrogen fixing bacterial community increased.

The increase in yield could be attributed to greater and consistently availability of plant nutrient throughout their growth period leading to enhance growth and yield of the crops. These findings are in conformity with those of Mal *et al.* (2013), who concluded through their field experiment that higher yield with enhanced yield attributing parameters in okra could be achieved by Integrated Nutrient Management consisting of reduced chemical fertilizer, organic manure and biofertilizer.

Our study clearly keep pace with studies of other workers where the positive effect of Integrated Nutrient Management was observed on growth and yield of green gram (Lal *et al.,* 2022) in availability of micro and macro nutrients in soil (Kaur and Kumar, 2023) , on yield and seed quality of pea (Kumar *et al*., 2023).

These findings will be useful to the researchers and other workers in future for innovative and validation of GAP for okra crop. Proper monitoring of the farmers to ensure soil based Integrated Nutrient Management (INM) with replacement chemical fertilizer by Bio-fertilizers, Integrated Pest Management with special emphasis of cultural, mechanical and biological practice, avoidance of WHO banded chemicals when chemical pesticides are applied and safety measures during application of chemical pesticides. This with increase the production potential of the soil as well as crop and the products will be of higher market potentiality. On the basis of the three successive years results, Good Agricultural Practices employing organic manures, bio-fertilizer and bio-pesticide may be recommended for okra cultivation for improved yield, yield attributes, higher farm income, safe food as well friendly environmental. If such farmers are organized in registered Producers' Groups and their products are channelized with proper marketing system without any middleman, the farmers will may get higher price and consequently their farm income will may be elevated.

Table 1. Effect of Conventional Method (CM) and Good Agricultural Practice (GAP) on some physical, biological and chemical characters of soil

Treatments	Soil microbial parameter- colony forming units (cfux10^5) g^{-1} of soil			Physical and chemical parameters of soil (after three years)					
	Azotobacter	PSB	KSB	pH	ElectricalConductance(dsm^{-1})	Organic Carbon (%)	Nitrogen (kg ha^{-1})	P_2O_5(kg ha^{-1})	K_2O(kg ha^{-1})
Base line data	1.96	1.72	2.48	6.17	0.17	0.29	178.85	64.08	90.77
CM	2.10	1.61	2.38	6.28	0.16	0.29	176.92	67.77	90.38
GAP	6.50	4.08	4.56	6.84	0.17	0.77	334.15	92.46	121.15
SEm±	0.16	0.19	0.19	0.08	0.01	0.04	15.91	3.86	3.68
CD at 5%	0.46	0.55	0.55	0.22	-	0.12	46.45	11.25	10.74

Table 2. Effect of Conventional Method (CM) and Good AgriculturalPractice (GAP) on some yield attributing characters and yield of Okra (pooled mean of three years)

Treatments	Plant height (cm)	Green pods weight (g)	Pod length (cm)	No. of pods $plant^{-1}$	Yield $plant^{-1}$ (g)	Yield (q ha^{-1})
CM	81.46	22.32	14.80	30.90	688.45	98.28
GAP	88.97	26.31	16.09	33.85	889.51	117.78
SEm±	0.76	0.20	.008	0.29	10.89	2.79
CD at 5%	2.27	0.58	0.021	0.83	30.48	8.27

Table 3. Effect of Conventional Method (CM) and Good Agricultural Practice(GAP) on some seed characters in okra

Treatments	Germination percentage		Seedling length (mm)	Vigour Index	Electrical conductivity (dsm-1)	Leaching sugar (µg ml^{-1})	Dehydrogenase (OD)	Green pod protain (%)	Seed protain (%)
	%	Arc-sin value							
CM	73.21	58.82	66.30	3195	3.04	0.080	0.32	1.09	11.02
GAP	81.55	64.56	74.00	4474	3.16	0.072	0.45	1.44	15.21
SEm±	2.49		0.966	109.97	0.126	.0035	0.02	0.095	0.581
CD at 5%	7.44		2.816	324.21	-	-	0.059	0.283	1.695

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