Studies on the management of soil fertility and sustainable productivity in Bhendi [*Abelmoschusesculentus* (L.)Moench]

ABSTRACT

A field experiment on COBh Hybrid Bhendi 4 was conducted in the Department of Horticulture, PanditJawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry, duringsummer 2022 with the objective of comparing the effects of organics and bioenhancers on soil fertilityrestoration and sustained vegetable production. The experiment was laid out in a Randomized BlockDesign with two replications involving two factors (fertilisers andbioenhancers) forming eighteentreatment combination in a factorial way (FRBD). The study material comprised of vermicompost andgoatmanure(organics)aswellaspanchagavyaandjivamirtham(bioenhancers),besidesrecommended FYMandN,P,Kfertilisersinvariouscombinations.Maximumplantheight(118.62cm),numberofprimary branches(5.02)atfinalharvest,maximumfruitlength(15.49cm)andfruitgirth(6.89cm),fruitweight(21.71g),number offruitsplant^{-1}(51.70),highestyield(891.60gplant^{-1}and 16.47tha^{-1})andmaximum drymatterproduction(5.74tha^{-1})wererecordedinthetreatmentreceivingRDFwith3 per centpanchagavya as foliarsprayon30,45,60 and75DAS.

Keywords:Vermicompost,Goatmanure,Panchagavya,Jivamirtham

1. INTRODUCTION

Vegetables are designated as “protective foods” in human diet due to their varying healthbenefits, attributable to their richness in vitamins, minerals, essential fatty acids, amino acids, dietaryfiber and other important bioactive compounds [1]. India ranks second in vegetable production and theproduction is estimated at191.77mMTfromanareaof 10.35mha[2].

Bhendi [*Abelmoschusesculentus*(L.)Moench] also known as Ladies finger valued for its tenderpods is one of the widely cultivated vegetables throughout the tropical and subtropical regions of theworld. Globally, India ranks first in bhendi production, with an area of 5.19 m ha, producing 6.37 m MTannuallywithaproductivityof12tonnes ha^{-1}[2].

Bhendiisofimmenseimportancewithlargepharmacological,nutritionalandindustrialapplications, with its curative property attributable to the presence of many bioactive compounds andtheirassociatedbioactivities[3].

Considering the commercial importance, many bhendi hybrids with high yield and tolerance tobiotic and abiotic stresses are in wide cultivation. However, these hybrids are input intensive, resultinginvarioussoilandenvironmentalhazards.Amongthemajornutrients,nitrogenbeinghighlyresponsive

for environmental hazards, besides its soring cost, the search for alternate approaches, includingIntegratedNitrogen Managementpracticesinanygivenenvironmentbecomesinevitable.

Integrated Nutrient Management (INM) is a flexible approach to minimize the use of chemicalfertilisers and maximize its use efficiency, thus remains the best alternative choice of growers formaintainingsoilhealthandsustainableproduction [2].

Organicmanures,whenefficientlyandeffectivelyusedcouldensuresustainablecropproductivity by immobilizing nutrients that are susceptible for leaching as the nutrients contained inmanuresarereleasedmoreslowlyandgetstoredforalongertimeinthesoil,ensuringlongerresidualeffects, improved root development and hence, higher crop yields [5]. The present study was hencecontemplated to determine the effect of organic sources of nutrients and bio enhancers on growth andyield ofhybridbhendi.

2. MATERIALSANDMETHODS

Afieldexperimenton'Effectoforganicsandbioenhancersongrowthandyieldofhybrid Bhendi[*Abelm oschusesculentus*(L.) Moench]' was performed in the Department of Horticulture, PanditJawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T. of Puducherry, Indiaduringsummer2022.The'bhendihybridCO4'(COBhH4)withacropdurationof110dayswasraised.The treatment materials for the study comprised of vermicompost, goat manure, panchagavya andjivamirtham,besides recommendedFarmYardManure(FYM) andN,P,Kfertilisers.

Panchagavya, a term used in Ayurveda represents a fermented product made out of fiveingredients of cow, such as milk, urine, dung, curd and clarified butter. It is a popular foliar nutritionprepared by organic growers of Tamil Nadu as an indigenous material and used widely for agriculturalandhorticulturalcrops[6].Jivamirthamreferstoaneco-friendlyorganicpreparationmadefromproductof cow. The products of cow have the ability to bring the flow of cosmic energy which in turn canrevitalizestheplantgrowthprocess [7].

Inthepresentexperiment,panchagavyawasappliedasfoliarsprayat3percentconcentrationon30,45,60and75daysaftersowing.Freshlypreparedjivamirthamwasappliedinthesoilatsowing,20and40days aftersowingalongwithirrigationwater.

The experiment was laid out in a Randomized Block Design with two replications involvingeighteen treatments (Table 1) in a factorial way (FRBD) and the study comprised of 2 factors *viz*.,Fertiliser(Factor1)andBioenhancers(Factor2).Factor1representdifferentfertilisercombinations

whilefactor2representthebioenhancersused. Thereweresixlevelsfor Factor1and threelevelsforFactor2,forming18treatmentcombinations.

2.1. Level offactors

2.1.1. Factor1– Fertilisers

F_0-Absolutecontrol

F_1-RDF(RecommendedDoseofFertilisers)

F_2 - 75 % N + RDP + RDK + RDFYM + 25 % N through

VermicompostF_3 - 75 % N + RDP + RDK + RDFYM + 25 % N through

Goat manureF_4-

50%N+RDP+RDK+RDFYM+50%NthroughVermicompostF_5-

50%N+RDP +RDK+RDFYM+50%NthroughGoatmanure

2.1.2.Factor2 –Bioenhancers

B_0-Absolutecontrol

B_1-3%Panchagavya foliarsprayon30,45,60and75DAS

B_2-Jivamirtham500Lha^{-1}assoil applicationthrice

withirrigation*viz.,*atsowing,20and45DAS

3. RESULTSANDDISCUSSION

3.1. Effect of organicsand bioenhancersongrowthparametersinbhendi

The influence of various treatments of the study on growth attributes of hybrid bhendi ispresented in Table 2. The application of RDF and foliar spraying of 3 per cent panchagavya on 30, 45,60 and 75 DAS (F_1B_1) has recorded the earliest flowering (38.52 days). The earliness in floweringobservedwiththeapplicationofRDFandpanchagavyamightbeduetotheacceleratedphotosynthesisandrapidtranslocationofphotosynthatestowardsinitiatingflowerbudsasreportedbyRameshetal. [8] from their study in tomato. The earliness could also be ascribed to the role played by the timelysupplyofadequatenutrientstotheplantsthroughtheuseofrecommendeddosefertilisers(200:100:100 kg ha^{-1}) as supply of phosphorus, to plants at right time in optimal quantity play a pivotalrole in initiationof flowerprimordiaasreported earlierbySinghetal.[9]and Singhetal.[10].

Flowering at the lowermost node is a preferred trait in bhendi and it was observed under RDFand foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS (F_1B_1 – 4.90) as well as RDFandsoilapplicationofjivamirtham500Lha^{-1}thricewithirrigation*viz.,*atsowing,20and45DAS

Table1.Treatmentparticulars

Sl. No.	Treatment	Treatmentdetails
1	T_1-F_0B_0	Absolute control
2	T_2-F_0B_1	3%Panchagavya foliarsprayon30,45,60and75DAS
3	T_3-F_0B_2	Jivamirtham 500 Lha^{-1} assoil application thrice withirrigation*viz*.,atsowing,20 and45 DAS
4	T_4-F_1B_0	RDF
5	T_5-F_1B_1	RDF+3%Panchagavyafoliarsprayon 30,45,60 and75DAS
6	T_6-F_1B_2	RDF+Jivamirtham500Lha^{-1}assoilapplicationthricewithirrigation*viz*.,at sowing,20and 45DAS
7	T_7-F_2B_0	75%N+RDP+RDK+RDFYM+25%Nthrough Vermicompost
8	T_8-F_2B_1	75%N+RDP+RDK+RDFYM+25%NthroughVermicompost+3%Panchagavyafoliarsprayon 30,45,60and75DAS
9	T_9-F_2B_2	75 % N + RDP + RDK + RDFYM + 25 % N through Vermicompost +Jivamirtham 500 L ha^{-1} as soil application thrice with irrigation *viz*., atsowing,20 and45 DAS
10	T_{10}-F_3B_0	75%N +RDP +RDK+RDFYM+ 25%Nthrough Goatmanure
11	T_{11}-F_3B_1	75%N +RDP +RDK+RDFYM+25%NthroughGoatmanure +3%Panchagavyafoliarsprayon 30,45,60and75 DAS
12	T_{12}-F_3B_2	75 % N + RDP + RDK + RDFYM + 25 % N through Goat manure +Jivamirtham 500 L ha^{-1} as soil application thrice with irrigation *viz*., atsowing,20 and45 DAS
13	T_{13}-F_4B_0	50%N+RDP+RDK+RDFYM+50%Nthrough Vermicompost
14	T_{14}-F_4B_1	50%N+RDP+RDK+RDFYM+50%NthroughVermicompost+3%Panchagavyafoliarsprayon 30,45,60and75 DAS
15	T_{15}-F_4B_2	50% N + RDP + RDK + RDFYM + 50% N through Vermicompost +Jivamirtham 500 L ha^{-1} as soil application thrice with irrigation *viz*., atsowing,20 and45 DAS
16	T_{16}-F_5B_0	50%N +RDP +RDK+RDFYM+ 50%Nthrough Goatmanure
17	T_{17}-F_5B_1	50%N+RDP+RDK+RDFYM+50%NthroughGoatmanure+3%Panchagavyafoliarsprayon 30,45,60and75 DAS
18	T_{18}-F_5B_2	50 % N + RDP + RDK + RDFYM + 50 % N through Goat manure +Jivamirtham 500 L ha^{-1} as soil application thrice with irrigation *viz*., atsowing,20 and45 DAS

(F_1B_2– 4.90).Theinfluenceonnodeoffirstfloweranthesisinbhendiwiththeapplicationof RDFmightbeduetotimelyavailabilityanduptakeofmajorplantnutrients.Theincreaseduptake ofNPKnutrientsby plants, could have resulted from increased plant metabolites in soil solution which are helpful inbuilding the plant tissues of bhendi as the nutrient acquisition power of a plant greatly depends on theconcentration of the ions in soil solution resulting in better growth and development as reported byPrabhuetal. [11]andVermaetal. [12].

The tallest plants at final harvest (118.62 cm) observed in plots treated with RDF and foliarspraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS as reported earlier by Muthuvel [13]could be the result of the growth enzymes present in panchagavya, favouring rapid cell division andmultiplicationasreportedbyVermaetal.[12].Panchagavyaisalsoreportedtocontainmacronutrientssuch as N, P, K, micronutrients, vitamins, amino acids and growth regulators such as auxins andgibberellins, which are essentially required for proper growth and development of plants resulting inincreased plant height as reported by Hathi et al. [14]. Nitrogen is the main constituent of protoplasm,cellnucleus,aminoacids,proteins,chlorophyllandmany otherplantmetabolicproducts,whilephosphorusisan essentialconstituent ofthe energy molecule adenosine tri-phosphate (ATP), thusplayin a key role in photosynthesis. Potassium plays a vital role in controlling water economy in the plantsgiving improved drought tolerance. The gradual increase in plant height with increasing dose of NPKandFYM,couldthus,provebeneficialforrootandshootgrowthofplantsassuggestedbyAmranetal. [15]andTyagietal.[16]inbhendi.

The application of RDF and foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75DAS(F_1B_1)hasrecordedmaximumbranchesplant^{-1}atfirstfloweringandfinalharvest(4.35and5.02).Thecombineduseoforganicandinorganicfertiliserscouldincreasecellpermeabilityandsupplyplantnutrients in a sustained manner (Kuppusamy et al.) [17] resulting in increased number of branchesplant^{-1}asreportedbyMajanbuetal.[18].

Theeffectofbioenhancersoninternodallengthofbhendiinthepresentstudywasinsignificantand such a report has been reported earlier by Jadhav et al. [19], while Oroka and Oke [20] reportedsignificantinfluenceoffertilisers oninternodallengthofbhendi.

TheapplicationofRDFandfoliarsprayingof3percentpanchagavyaon30,45,60and75 DAS (F_1B_1) has recorded maximum dry matter production (5.74).The dry matter production of thecropisanindexoftheplantgrowthandthedrymatteryielddeterminespartlyorfullytheyieldofthe

crop. This is attributable to the increased availability of nitrogen with the combined use of organic andinorganicsourcesofnutrients.ThiswasinaccordancewiththefindingsofAnburaniandManivannan [21] in brinjal. The increased dry matter production is further attributable to the well established rootsysteminadditiontoincreasedplantheight,numberofbranchesandleavesasreportedbyTripathyetal.[22] withthecombinedapplicationofchemicalfertilisersandstimulants.

3.2. Effect of organicsand bioenhancersonyieldparametersinbhendi

The effect of treatment on yield parameters of hybrid bhendi is given in Table 3. The longestfruitsobservedinRDFwith foliarspraying of3 percent panchagavyaon 30,45, 60 and 75 DAS(F_1B_1 - 15.49 cm) could have resulted from the supplementation of micronutrients by organic sourcesappliedwithinorganicsourcesofnitrogen,phosphorusandpotassiumasexpressedbySinghetal.[23] inbhendi.Theapplicationofnitrogenalsofavoursthemetabolicandauxinactivitiesinplant(Yadav et al.) [24] and on decomposition releases nutrient in a sustained manner throughout the plantlifecycle leadingtohigherfruitlength(Akhteretal.)[25].

The improved fruit girth (6.89 cm) recorded in F_1B_1could be attributed to the increasedavailabilityofNPKatcriticalstagesofthecropgrowthresultinginearlyestablishment,vigorousgrowt hand development of plants thus leading to longer and wider fruits as observed by Naidu et al. [26].Further, the integrated use of chemical fertiliser and vermicompost resulting in balanced fertilizationcould have enhanced the photosynthetic activity through increased leaf area and resulted in buildup ofadequate food reserve for formation and elongation of cells. The synthesized photosynthates mighthave got translocated to the growing fruits which are in greater demand of assimilates consequentlyleadingtogreaterthicknessoffruit(Kumaretal.) [27].

The maximum fruit weight of bhendi was observed in RDF and foliar spraying of 3 per centpanchagavyaon30,45,60and75DAS(F_1B_1– 21.71g).Theincreasedphotosyntheticareaandbettertranslocation of photosynthates resulting out of the supply of adequate nutrients in the treatment couldhave been responsible for large sized fruits with more number of seeds $fruits^{-1}$ resulting in increasedfruit weight as reported earlier by Mal et al. [28]. The increased concentration of chlorophyll content ofpanchagavyatreatedplantsresultinginenhancedphotosyntheticefficiencymighthavealsocontributedto the fruit weight (Swarnam et al.) [29], as fermented Panchagavya is reported to be rich in N, P, K, Sandmicronutrients.

Theapplicationofinorganicandorganicsourcesofnutrientsinrightproportioninthetreatmentreceivingrdfandfoliarsprayingof3percentpanchagavyaon30,45,60and75DAShasleadtotheproduction of more number of fruits plant^{-1} (F_1B_1 - 51.70) which could be attributable to the maximumnumber of flowers produced with improved nutrient availability (Kuppusamy et al.) [17]. Accumulationof cytokinin and auxin in the auxillary buds as reported by Swain et al. [30] in panchagavya treatedplantscouldhavealsoresultedinmorenumber offruits plant^{-1}.

The maximum yield (891.60 g plant^{-1} / 16.47 t ha^{-1}) was observed in treatments receiving RDFand foliar spraying of 3 per cent panchagavya on 30, 45, 60 and 75 DAS (F_1B_1). This could have resultedfrom the improved metabolic and auxin related activities in plants under optimal nutritional level asreportedbySinghetal.[10].Foliarsprayofpanchagavyaat3percentcouldhaveresultedinenhancedyieldas panchagavyaisreportedtocontainbeneficialmicrobesnamelylacticacidbacteria(*Lactobacillus*),yeast(*Saccharomyces*),actinomyces(*Streptomyces*),photosyntheticbacteria(*Rhodopseudomonas*)and certainfungi*(Aspergillus)*,asreportedbyVermaetal.[12].

4. CONCLUSION

The results of the experiment clearly revealed the significance of applying 100 per cent RDFalong with foliar spray of 3 per cent panchagavya at 30, 45, 60 & 75 DAS in terms of growth and yieldparametersinbhendi.

Table2.Effectoforganicsandbioenhancersongrowthattributesofbhendi

Treatment	Days tofloweri ng	Nodeof firstfloweranth esis	Plant height atflowering (cm)	Plant height atfinal harvest(cm)	Primaryb ranchesp lant^{-1}at flowering	Primarybranc hesplant^{-1}atfinal harvest	Internodal length(cm)	Dry matterpro duction(t ha^{-1})
T_1- F_0B_0	44.25	5.50	19.78	44.84	2.35	3.10	2.30	0.33
T_2- F_0B_1	49.00	5.40	17.06	51.72	2.60	3.20	2.49	0.85
T_3- F_0B_2	51.80	5.40	17.22	49.93	2.57	3.13	2.49	0.57
T_4- F_1B_0	40.40	5.00	24.51	104.99	4.20	4.70	3.34	3.81
T_5- F_1B_1	38.52	4.90	23.27	118.62	4.35	5.02	3.48	5.74
T_6- F_1B_2	39.50	4.90	23.72	118.24	4.32	4.80	3.39	4.17
T_7- F_2B_0	41.71	5.20	25.43	87.54	3.40	4.10	2.93	3.02
T_8- F_2B_1	41.10	5.00	24.59	103.49	4.02	4.60	3.28	3.76
T_9- F_2B_2	41.12	5.10	24.90	97.41	4.00	4.52	3.23	3.76
T_{10}- F_3B_0	42.20	5.20	25.66	87.26	3.37	4.10	2.93	2.89
T_{11}- F_3B_1	41.37	5.10	25.08	96.12	3.80	4.40	3.26	3.62
T_{12}- F_3B_2	41.60	5.20	25.22	92.96	3.50	4.40	3.08	3.61
T_{13}- F_4B_0	46.37	5.30	30.90	69.87	2.85	3.60	2.73	1.47
T_{14}- F_4B_1	42.50	5.20	25.92	83.13	3.37	4.10	2.90	2.76
T_{15}- F_4B_2	44.80	5.30	28.20	75.34	3.15	3.75	2.93	2.58
T_{16}- F_5B_0	46.62	5.40	30.96	55.66	2.70	3.33	2.71	1.40
T_{17}- F_5B_1	42.50	5.30	27.79	79.32	3.30	4.00	2.85	2.75
T_{18}- F_5B_2	45.97	5.30	29.82	73.85	2.92	3.70	2.84	1.56

Factor	SEd	CD (p=0.05)	SEd	CD (p=0.05)	SEd	CD (p=0.05)	SEd	CD (p=0.05)	SEd	CD (p=0.05)	SEd	CD (p=0.05)	SEd	CD (p=0.05)	SEd	CD (p=0.05)
Fertilisers	1.246	2.63	0.136	0.29	1.349	2.84	5.620	11.86	0.271	0.57	0.236	0.50	0.223	0.47	0.853	1.80
Bioenhancers	0.881	NS	0.096	NS	0.954	NS	3.974	8.39	0.191	NS	0.167	NS	0.158	NS	0.603	NS
Fertilisersx Bioenhancers	2.159	NS	0.236	NS	2.338	NS	9.740	NS	0.470	NS	0.410	NS	0.387	NS	1.478	NS

Table3.Effectoforganicsandbioenhancersonyieldattributesofbhendi

Treatment	Fruitlength (cm)		Fruitgirth(cm)		Individual fruitweight(g)		Numberoffruits plant^{-1}		Yieldplant^{-1}(g)		Yieldhectare^{-1}(tonnes)	
T_1- F_0B_0	11.60		5.49		12.26		12.75		126.40		2.90	
T_2- F_0B_1	12.40		6.23		14.17		15.66		170.65		3.88	
T_3- F_0B_2	11.83		5.85		12.65		12.90		140.35		3.76	
T_4- F_1B_0	15.05		6.86		19.65		39.22		676.40		16.22	
T_5- F_1B_1	15.49		6.89		21.71		51.70		891.60		16.47	
T_6- F_1B_2	15.07		6.89		20.56		49.45		880.80		16.35	
T_7- F_2B_0	14.01		6.66		17.91		36.00		588.05		13.97	
T_8- F_2B_1	14.74		6.85		19.54		38.30		646.15		15.42	
T_9- F_2B_2	14.70		6.84		19.20		37.50		622.45		15.02	
T_{10}-F_3B_0	13.88		6.60		17.70		35.80		579.00		11.67	
T_{11}-F_3B_1	14.31		6.77		18.42		36.90		594.90		14.15	
T_{12}-F_3B_2	14.23		6.72		18.17		36.30		592.30		14.05	
T_{13}-F_4B_0	12.99		6.37		15.36		22.50		326.35		5.70	
T_{14}-F_4B_1	13.67		6.54		16.95		35.20		548.60		7.03	
T_{15}-F_4B_2	13.26		6.47		16.46		31.90		493.10		6.80	
T_{16}-F_5B_0	12.56		6.29		14.35		16.32		181.75		5.27	
T_{17}-F_5B_1	13.53		6.53		16.60		35.02		503.65		6.90	
T_{18}-F_5B_2	13.23		6.42		16.16		23.60		334.15		6.61	
Factor	**SEd**	**CD(p =0.05)**	**SEd**	**CD(p =0.05)**	**SEd**	**CD(p =0.05)**	**SEd**	**CD(p =0.05)**	**SEd**	**CD(p =0.05)**	**SEd**	**CD(p =0.05)**
Fertilisers	0.635	1.34	0.200	0.42	0.854	1.80	2.461	5.19	38.551	81.34	2.946	6.22
Bioenhancers	0.449	NS	0.142	NS	0.604	1.27	1.740	3.67	27.259	57.51	2.083	NS
Fertilisersx Bioenhancers	1.101	NS	0.348	NS	1.480	NS	4.265	NS	66.804	NS	5.105	NS

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