

**“EFFECT OF SPACING AND ORGANIC
MANURE ON GROWTH AND YIELD
PERFORMANCE OF INDIAN SPINACH
(*Basella rubra* L.)”**

By

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November, 2021

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A thesis submitted to the

Dr. BALASAHEB SAWANT KONKAN KRISHI VIDYAPEETH,
DAPOLI, (Agricultural University)
DIST. RATNAGIRI (M.S.), INDIA

In partial fulfillment of the requirements for the degree of

**MASTER OF SCIENCE
(HORTICULTURE)**

in

VEGETABLE SCIENCE

by

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C E R T I F I C A T E

This is to certify that the thesis entitled **“Effect of spacing and organic manure on growth and yield performance of Indian spinach (*Basella rubra* L.)”** submitted to the College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Dist. Ratnagiri, (Maharashtra State), in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE (HORTICULTURE)** in **VEGETABLE SCIENCE**, embodies the results of a piece of bona-fide research carried out by **Mr. Tejesh Shirish Pawar** under my guidance and supervision. No part of the thesis has been submitted for any other degree or diploma. All the assistance and help received during the course of investigation and the sources of literature have been duly acknowledged by him.

Place: Dapoli
Dated: /11/2021

Dr. P. C. Haldavanekar
Chairman,
Advisory Committee
and
Research Guide

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ABSTRACT

The present investigation entitled, “Effect of spacing and organic manure on growth and yield performance of Indian spinach (*Basella rubra* L.)” was conducted at College of Horticulture, Dapoli, Dist. Ratnagiri (M.S) during the *kharif* and *summer* season in the academic year 2019-20 in Split Plot Design with three replications. Two factors were studied during the investigation *viz.*, spacing S₁ (50 × 30 cm), S₂ (50 × 45 cm) and S₃ (50 × 60 cm) as main plot treatments and b) organic manure levels *viz.*, M₁ (FYM @ 10 t/ha + 100:50:50 kg/ha NPK), M₂ (vermicompost @ 5 t / ha), M₃ (poultry manure @ 4 t/ha) and

M₄ (neem cake @ 2 t/ha) as sub-plot treatments. Thus, in all 12 treatment combinations were studied.

Under different spacings, organic manures and their interactions showed significant variation in growth parameters, yield attributing characters and quality parameters of Indian spinach.

With regards to variation in spacing, growth parameters and yield attributing characters of Indian spinach at all growth stages varied significantly. The growth observations of Indian spinach *viz.*, plant height, stem diameter, number of leaves, inter-nodal length, number of branches and leaf area varied significantly among various spacings. The highest plant height (51.05 cm), stem diameter (16.78 mm) and inter-nodal length (3.55 cm) was recorded with treatment S₃. The highest number of leaves (52.61), number of branches (12.47) and leaf area (238.82 cm²) was recorded with treatment S₂. Whereas, the yield attributing characters were also noticed significant effect. The highest herbage yield per plant (109.71 g) and total herbage yield per plant (406.23 g) was recorded with treatment S₃. While, the herbage yield per plot (5.14 kg), total herbage yield per plot (24.95 kg) and total herbage yield per hectare (27.72 t) was recorded with treatment S₁.

However, the chemical parameters of Indian spinach were non- significantly varied except dry matter and shelf life. The highest dry matter (14.81 %) and shelf life (33.58 hours) was recorded in treatment S₃.

The chemical properties of soil *viz.*, soil pH, EC, available nitrogen, phosphorous and potassium were significantly varied. The highest pH (5.64), available nitrogen (333.20 kg/ha), available phosphorous (16.03 kg/ha) and available potassium

(359.89 kg/ha) was recorded with treatment S₃. The highest soil EC (0.21 dSm⁻¹) was recorded with treatment S₁.

Further, observing the effect of different organic manures on growth, yield and chemical parameters of Indian spinach were found significant at all growth stages. The highest plant height (50.54 cm), stem diameter (17.63 mm), number of leaves (55.59), inter-nodal length (3.37 cm), number of branches (11.72) and leaf area (240.15 cm²) were observed with treatment M₁. Also, the highest herbage yield per plant (109.49 g), highest herbage yield per plot (4.32 kg), total herbage yield per plant (404.58 g), total herbage yield per plot (20.75 kg) and total herbage yield per hectare (23.05 t) were recorded with treatment M₁. Whereas, the highest vitamin A (3.71 mg/100 g), dry matter (14.88 %) were recorded with treatment M₁ and ascorbic acid (68.67 mg/100 g) and shelf life (33.33 hours) were recorded with treatment M₃.

The chemical properties of soil *viz.*, soil pH, EC, available nitrogen, phosphorous and potassium were also significantly varied. The highest pH (5.67), EC (0.20 dSm⁻¹), available nitrogen (327.94 kg/ha), available phosphorous (14.91 kg/ha) and available potassium (351.82 kg/ha) was recorded with treatment M₃.

With regards to interaction effect spacing and organic manures had significant effect on growth and yield parameters of Indian spinach. The highest plant height (53.35 cm), stem diameter (19.86 mm) and inter-nodal length (4.13 cm) was recorded with treatment combination S₃M₁. The highest number of leaves (58.18), number of branches (12.74) and leaf area (253.32 cm²) were observed with treatment combination S₂M₁. The highest herbage yield per plant (110.14 g) and total herbage

yield per plant (409.23 g) was recorded with treatment combination S₃M₁ whereas, the highest herbage yield per plot (5.87 kg), total herbage yield per plot (28.55 kg) and total herbage yield per hectare (31.72 t) were recorded with treatment combination S₁M₁.

The interaction effect on quality parameters had non-significant effect except dry matter and shelf life. The highest dry matter (16.42 %) was recorded with treatment combination S₃M₁. And highest shelf life (33.33 hours) was recorded with treatment combination S₃M₃.

The chemical properties of soil *viz.*, soil pH, EC, available nitrogen, phosphorous and potassium were found significantly varied. The highest pH (5.83), available nitrogen (335.55 kg/ha), available phosphorous (16.40 kg/ha) and available potassium (361.41 kg/ha) was recorded with treatment combination S₃M₃. The highest soil EC (0.23 dSm⁻¹) was recorded with treatment combination S₁M₃.

Thus, from the present investigation entitled, “effect of spacing and organic manure on growth and yield performances of Indian spinach” it was concluded that the treatment FYM @ 10 t /ha + 100:50:50 kg/ha NPK performed better for yield maximization in Indian spinach at 50 × 30 cm spacing. Thus, integrated approach towards nutrient management is essential for yield maximization in Indian spinach under konkan agro-climatic condition. However, it needs confirmation by conducting the same field investigation for successive two years.

डॉ. बाळासाहेब सावंत कोकण कृषि विद्यापीठ, दापोली
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प्रबंध शिर्षक	:- “अंतर आणि सेंद्रिय खते यांचा मायाळूच्या वाढीवर व उत्पन्नावर परिणाम”
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प्रबंध गोषवारा

प्रस्तुत प्रयोग, अंतर आणि सेंद्रिय खते यांचा मायाळूच्या वाढीवर व उत्पन्नावर परिणाम” हा उद्यानविद्या महाविद्यालय दापोली, जि. रत्नागिरीच्या प्रायोगिक क्षेत्रात खरीप आणि उन्हाळा या हंगामात घेण्यात आले.

हा प्रयोग दोन घटक तीन प्रतिकृतीसह क्रम गुणीत यादृच्छिक गट रूपरेषेमध्ये घेण्यात आला. उदा. पहिला घटक तीन वेगवेगळ्या अंतरांचा समावेश जसे एस-१ (५० X ३० सेंमी.), एस-२, (५० X ४५ सेंमी.), एस-३, (५० X ६० सेंमी.), दुसरा घटक चार वेगवेगळ्या सेंद्रिय घटकांचा समावेश जसे एम-१, (शेणखत @ १० टन प्रति हेक्टर + नत्र १००:५०:५० किलो प्रति हेक्टर), एम -२ (गांडूळखत @ ५ टन प्रति हेक्टर), एम -३ (पोल्ट्री खत @ ४ टन प्रति हेक्टर) आणि एम-४ (निम पेंड @ २ टन प्रति हेक्टर) अशाप्रकारे सर्व बारा उपचार मिश्रणांचा अभ्यास करण्यात आला. अंतर, सेंद्रिय खते त्यांचा एकत्रितपणे मायाळूच्या वाढीवर, उत्पन्नावर आणि भौतिक रासायनिक गुणधर्म यावर लक्षणीय फरक दिसून आले.

मायाळूच्या वाढीचे निरीक्षण उदा. वनस्पतींची उंची, सरासरी पान क्षेत्र, देठाचा व्यास, पानांची संख्या, दोन पेरामधील अंतर आणि फांद्यांची संख्या वेगवेगळ्या अंतरामध्ये लक्षणीय बदल दिसून आले. वनस्पतीची सर्वाधिक उंची (५१.०५ सेंमी.), देठाचा व्यास (१६.७८ मी. मी.), दोन पेरामधील अंतर (३.५५ सेंमी.) ५० X ६० अंतरावर नोंदवली गेली. तसेच सर्वाधिक पाने (५२.६१), शाखा संख्या (१२.४७) आणि पानांचे क्षेत्र (२३८.८२ सेंमी^२) एस-२ मध्ये नोंदवली गेली. तर उत्पन्नामध्ये प्रत्येक कापणीच्या अंतराने लक्षणीय परिणाम दिसून आले. सर्वाधिक प्रति वनस्पती उत्पन्न (१०९.७१ ग्रॅ) आणि एकूण वनस्पतीचे उत्पन्न (४०६.२३ ग्रॅ) विस्तृत अंतरामध्ये (एस-३) नोंदविले गेले. तर प्रत्येक

प्लॉटवर (५.१४ कि.ग्रॅ.), तर वनस्पतीचे प्रत्येक भूखंडावर एकूण उत्पन्न (२४.९५ कि.ग्रॅ.) आणि एकूण औषधी वनस्पतीचे हेक्टरी उत्पादन (२७.७२ टन) एस-१ मध्ये नोंदविले गेले.

मायाळूच्या रासायनिक मापदंडामध्ये कोरडे पदार्थ आणि टिकाऊ कालावधी वगळता लक्षणिय बदल दिसून आले नाहीत. एस-३ मध्ये सर्वाधिक शुष्क घटक (१४.८१ %) आणि टिकाऊ कालावधी (३३.५८ तास) नोंदविले गेले.

मातीचे रासायनिक गुणधर्म जसे की, पीएच, इसी, उपलब्ध नायट्रोजन, स्फुरद आणि पालाश यांवर महत्वपूर्ण परिणाम दिसून आले. सर्वाधिक पी.एच. (५.६४) उपलब्ध नत्र (३३३.२० कि.ग्रॅ.), उपलब्ध स्फुरद (१६.०३ कि.ग्रॅ.) आणि पालाश (३५९.८९ कि.ग्रॅ. प्रती हेक्टर) उपचार एस-३ मध्ये नोंदविले गेले. तसेच सर्वाधिक इसी (०.२१ डीसीएम^{-१}) उपचार एस-१ मध्ये नोंदविले गेले.

पुढे मायाळूच्या वाढीवर उत्पन्नावर आणि रासायनिक मापदंडावर वेगवेगळ्या सेंद्रिय खतांचा परिणाम पाहता सर्व वाढीच्या टप्प्यावर महत्वपूर्ण बदल दिसून आले. सर्वाधिक वनस्पतीची उंची (५०.५४ सेंमी.), देठाचा व्यास (१७.६३ एम.एम.), पानांची संख्या (५५.५९), दोन पेरामधील अंतर (३.३७ सेंमी.) शाखांची संख्या (११.७२) आणि पानाचे क्षेत्र (२४०.१५ सेंमी^२) सेंद्रिय खत एम-१ मध्ये दिसून आले. तसेच प्रती वनस्पती उत्पन्न (१०९.४९ ग्रॅ.) प्रती प्लॉट उत्पन्न (४.३२ कि.ग्रॅ.), प्रत्येक झाडाचे एकूण वनस्पती उत्पन्न (४०४.५८ ग्रॅ.), एकूण प्रती प्लॉट उत्पन्न (२०.७५ कि.ग्रॅ. प्रती हेक्टर) आणि एकूण हेक्टरी उत्पन्न (२३.०५ टन प्रती हेक्टर) सेंद्रिय खत एम-१ मध्ये आढळून आले. तर सर्वाधिक अ जीवनसत्व (३.७१ मि.ग्रॅ. प्रती १०० ग्रॅ.), शुष्क घटक (१४.८८ %) एम-१ मध्ये नोंदविले गेले. आणि क जीवनसत्व (६८.६७ मि.ग्रॅ. प्रती १०० ग्रॅ.) आणि टिकाऊ कालावधी ३३.३३ तास एम-३ मध्ये नोंदविले गेले. तसेच सर्वाधिक पीएच (५.६७), इसी (०.२० डीसीएम^{-१}), उपलब्ध नत्र (३२७.९४ कि.ग्रॅ. प्रती हेक्टर), स्फुरद (१४.९१ कि.ग्रॅ. प्रती हेक्टर) आणि पालाश (३५१.८२ कि.ग्रॅ. प्रती हेक्टर) उपचार एम-३ मध्ये नोंदविले गेले.

अंतर आणि सेंद्रिय खत यांच्या परस्पर संवादामध्ये मायाळूच्या वाढीवर आणि उत्पन्नाच्या मापदंडावरती महत्वपूर्ण बदल दिसून आले. एस-३ एम-१ मध्ये वनस्पतीची सर्वाधिक उंची (५३.३५ सेंमी.), देठाचा व्यास (१९.८६ एम.एम.) आणि दोन पेरामधील अंतर (४.१३ सेंमी) नोंदविली गेली. तसेच एस-२ एम-१ मध्ये सर्वाधिक पाने (५८.१८), शाखांची संख्या (१२.७४) आणि पानांचे क्षेत्र (२५३.३२ सेंमी^२) आढळून आले. सर्वाधिक प्रती वनस्पती उत्पन्न (११०.७४ ग्रॅ.) आणि एकूण वनस्पती उत्पन्न (४०९.२३ ग्रॅ.) एस-३, एम-१ मध्ये नोंदविले गेले. तर प्रति प्लॉट उत्पन्न (५.८७ कि.ग्रॅ.), एकूण प्लॉट उत्पन्न (२८.५५) कि.ग्रॅ. एकूण हेक्टरी उत्पन्न (३१.७२ टन) एस-१ एम-१ मध्ये नोंदविले गेले. कोरडे पदार्थ आणि टिकाऊ कालावधी यांच्या गुणवत्तेच्या मापदंडामध्ये परस्पर संवादाच्या प्रभावामुळे महत्वपूर्ण परिणाम दिसून आले. एस-३ एम -१ मध्ये सर्वाधिक कोरडे पदार्थ (१६.४२ %) नोंदविले गेले आणि एस-३ एम-३ मध्ये सर्वाधिक टिकाऊ कालावधी ३३.३३ तास नोंदविली गेली. तसेच सर्वाधिक पीएच (५.८३), उपलब्ध नत्र (३३५.५५ कि.ग्रॅ. प्रती हेक्टर) स्फुरद (१६.४० कि.ग्रॅ. प्रती हेक्टर) आणि पालाश (३६१.४१ कि.ग्रॅ. प्रती हेक्टर)

एस-३ एम-३ मध्ये नोंदविले गेले. आणि सर्वाधिक इसी (०.२३ डीसीएम^१) एस-१ एम-३ मध्ये नोंदविले गेले.

अशाप्रकारे मायाळूच्या वाढीवर आणि उत्पन्न यांच्या कामगिरीवर अंतर आणि सेंद्रिय खतांचा परिणाम या शिर्षकाच्या तपासणीतून असे निष्कर्ष काढले गेले की, वेगवेगळ्या सेंद्रिय खतांमध्ये एम-१ (एफ.वाय.एम @ १० टन प्रति हेक्टर + १००:५०:५० किलो प्रति हेक्टर नत्र: स्फुरद: पालाश) या सेंद्रिय खताची चांगली कामगिरी दिसून आली. अशाप्रकारे मायाळूच्या उत्पन्नामध्ये सेंद्रिय खत शेणखत @ १० टन प्रति हेक्टर + १००:५०:५० किलो प्रति हेक्टर नत्र: स्फुरद: पालाश आणि ५० X ३० सेंमी. अंतर यांचे सकारात्मक बदल दिसून आले.

डॉ. बालासाहेब सावंत कोंकण कृषि विद्यापीठ, दापोली
बागवानी कॉलेज, दापोली

प्रबंध का शीर्षक	:- “भारतीय पालक की वृद्धि और उपज प्रदर्शन पर अंतर और जैविक खाद का प्रभाव (बसेला रूब्रा एल.)”
छात्र का नाम	:- कु. पवार तेजेश शिरीष
पंजीकरण संख्या	:- एचडीपीएम /१८/०१६५
अनुसंधान मार्गदर्शक का नाम	:- डॉ. पी. सी. हलदवणेकर , सहयोगी अधीक्षक बागवानी महाविद्यालय, मुलदे डॉ. बा. सा. को. कृ. वि., दापोली.
प्रस्तुती का साल	:- नवंबर, २०२१

सार

वर्तमान जांच शीर्षक, “भारतीय पालक (बसेला रूबरा एल) की वृद्धि और उपज प्रदर्शन पर अंतर और जैविक खाद का प्रभाव” बागवानी कॉलेज, दापोली, जिला रत्नागिरी (एम.एस) में आयोजित किया गया था। शैक्षणिक वर्ष २०१९-२० में खरीफ और गर्मी के मौसम के दौरान स्प्लिट प्लॉट डिजाइन में तीन प्रतिकृति के साथ किया गया था। जांच के दौरान दो कारकों का अध्ययन किया गया था, जैसे एस १ (५० × ३० सेमी), एस २ (५० × ४५ सेमी) और एस ३ (५० × ६० सेमी) को मुख्य प्लॉट उपचार के रूप में और बी) जैविक खाद का स्तर अर्थात् एम १ (एफ वाई एम @ १० टन / हेक्टेयर + १००:५०:५० किग्रा / हेक्टेयर एनपीके), एम २ (वर्मिकम्पोस्ट @ ५ टन / हेक्टेयर), एम ३ (पोल्ट्री खाद @ ४ टन / हेक्टेयर) और एम ४ (नीम केक @ २ टन / हेक्टेयर) सब-प्लॉट उपचार के रूप में। इस प्रकार, सभी १२ उपचार संयोजनों का अध्ययन किया गया।

विभिन्न अंतरालों के तहत, जैविक खाद और उनकी परस्पर क्रिया ने भारतीय पालक के विकास मापदंडों, उपज के लक्षण और गुणवत्ता मापदंडों में महत्वपूर्ण भिन्नता दिखाई।

अंतर में भिन्नता के संबंध में, वृद्धि के मानकों और सभी विकास चरणों में भारतीय पालक के गुणों के कारण उपज में काफी भिन्नता है। भारतीय पालक जैसे पौधे की ऊंचाई, तने का व्यास, पत्तियों की संख्या, अंतर-नोडल लंबाई, शाखाओं की संख्या और पत्ती

क्षेत्र की वृद्धि अवलोकन विभिन्न रिक्ति के बीच महत्वपूर्ण रूप से भिन्न होते हैं। उच्चतम पौधे की ऊंचाई (५१.०५ सेमी), स्टेम व्यास (१६.७८ मिमी) और इंटर-नोडल लंबाई (३.५५ सेमी) उपचार एस_३ के साथ दर्ज की गई थी। उपचार एस_२ के साथ पत्तियों की उच्चतम संख्या (५२.६१), शाखाओं की संख्या (१२.४७) और पत्ती क्षेत्र (२३८.८२ सेमी^२) दर्ज की गई। जबकि, उपज को जिम्मेदार ठहराने वाले लक्षणों पर भी महत्वपूर्ण प्रभाव देखा गया। उपचार एस_३ के साथ प्रति पौधा उच्चतम जड़ी-बूटी उपज (१०९.७१ ग्राम) और प्रति पौधा कुल जड़ी-बूटी की उपज (४०६.२३ ग्राम) दर्ज की गई। जबकि, प्रति प्लॉट (५.१४ किग्रा) जड़ी-बूटी की उपज, प्रति प्लॉट (२४.९५ किग्रा) की कुल जड़ी-बूटी की उपज और प्रति हेक्टेयर (२७.७२ टन) की कुल जड़ी-बूटी की उपज उपचार एस_१ के साथ दर्ज की गई थी।

हालांकि, सूखे पदार्थ और शेल्फ लाइफ को छोड़कर भारतीय पालक के रासायनिक पैरामीटर गैर-महत्वपूर्ण रूप से भिन्न थे। उपचार एस_३ में उच्चतम शुष्क पदार्थ (१४.८१ %) और शेल्फ जीवन (३३.५८ घंटे) दर्ज किया गया था।

इसके अलावा, भारतीय पालक की वृद्धि, उपज और रासायनिक मापदंडों पर विभिन्न जैविक खादों के प्रभाव को देखते हुए सभी विकास चरणों में महत्वपूर्ण पाया गया। उच्चतम पौधे की ऊंचाई (५०.५४ सेमी), तने का व्यास (१७.६३ मिमी), पत्तियों की संख्या (५५.५९), अंतर-नोडल लंबाई (३.३७ सेमी), शाखाओं की संख्या (११.७२) और पत्ती क्षेत्र (२४०.१५ सेमी^२) उपचार एम_१ के साथ देखा गया। साथ ही, प्रति पौधा उच्चतम जड़ी-बूटी उपज (१०९.४९ ग्राम), प्रति प्लॉट उच्चतम हर्ब उपज (४.३२ किग्रा), प्रति पौधा कुल जड़ी-बूटी उपज (४०४.५८ ग्राम), प्रति प्लॉट कुल जड़ी-बूटी की उपज (२०.७५ किग्रा) और प्रति हेक्टेयर कुल जड़ी-बूटी की उपज (२३.०५ टन) उपचार एम_१ के साथ दर्ज किए गए थे। जबकि, उच्चतम विटामिन ए (३.७१ मिलीग्राम / १०० ग्राम), शुष्क पदार्थ (१४.८८ %) उपचार एम_१ और एस्कॉर्बिक एसिड (६८.६७ मिलीग्राम / १०० ग्राम) और शेल्फ जीवन (३३.३३ घंटे) उपचार एम_३ के साथ दर्ज किया गया था।

मिट्टी के रासायनिक गुण अर्थात् मिट्टी का पीएच, ईसी, उपलब्ध नाइट्रोजन, फॉस्फोरस और पोटेशियम भी काफी भिन्न थे। उच्चतम पीएच (५.६७), इसी ((०.२० डीसीएम^{-१}), उपलब्ध नाइट्रोजन (३२७.९४ किग्रा / हेक्टेयर), उपलब्ध फॉस्फोरस (१४.९१ किग्रा / हेक्टेयर) और उपलब्ध पोटेशियम (३५१.८२ किग्रा / हेक्टेयर) उपचार एम_३ के साथ दर्ज किया गया।

पारस्परिक प्रभाव के संबंध में अंतर और जैविक खाद का भारतीय पालक के विकास और उपज मानकों पर महत्वपूर्ण प्रभाव पड़ा। उच्चतम पौधे की ऊंचाई (५३.३५ सेमी), स्टेम व्यास (१९.८६ मिमी) और इंटर-नोडल लंबाई (४.१३ सेमी) उपचार संयोजन एस_३ एम_१ के साथ दर्ज की गई थी। उपचार संयोजन एस_२ एम_१ के साथ सबसे अधिक संख्या में पत्ते (५८.१८), शाखाओं की संख्या (१२.७४) और पत्ती क्षेत्र (२५३.३२ सेमी^२) देखे गए। प्रति पौधा उच्चतम हर्ब उपज (११०.७४ ग्राम) और प्रति पौधा कुल जड़ी-बूटी की उपज (४०९.२३ ग्राम) उपचार संयोजन एस_३ एम_१ के साथ दर्ज की गई, जबकि, प्रति प्लॉट उच्चतम हर्ब उपज (५.८७ किग्रा), प्रति प्लॉट कुल जड़ी-बूटी उपज (२८.५५ किग्रा) और कुल उपचार संयोजन एस_१ एम_१ के साथ प्रति हेक्टेयर हर्ब उपज (३१.७२ टन) दर्ज की गई।

गुणवत्ता मानकों पर अंतःक्रियात्मक प्रभाव का शुष्क पदार्थ और शेल्फ जीवन को छोड़कर गैर-महत्वपूर्ण प्रभाव पड़ा। उच्चतम शुष्क पदार्थ (१६.४२ %) उपचार संयोजन एस_३ एम_१ के साथ दर्ज किया गया था। और उच्चतम शेल्फ जीवन (३३.३३ घंटे) उपचार संयोजन एस_३ एम_३ के साथ दर्ज किया गया था।

मिट्टी के रासायनिक गुण जैसे मिट्टी पीएच, ईसी, उपलब्ध नाइट्रोजन, फॉस्फोरस और पोटेशियम काफी भिन्न पाए गए। उच्चतम पीएच (५.८३), उपलब्ध नाइट्रोजन (३३५.५५ किग्रा / हेक्टेयर), उपलब्ध फॉस्फोरस (१६.४० किग्रा / हेक्टेयर) और उपलब्ध पोटेशियम (३६१.४१ किग्रा / हेक्टेयर) उपचार संयोजन एस_३ एम_३ के साथ दर्ज किया गया था। उच्चतम मृदा इसी (०.२३ डीसीएम^{-१}) को उपचार संयोजन एस_१ एम_३ के साथ दर्ज किया गया था।

इस प्रकार, "भारतीय पालक की वृद्धि और उपज प्रदर्शन पर अंतर और जैविक खाद का प्रभाव" शीर्षक वाली वर्तमान जांच से यह निष्कर्ष निकाला गया कि उपचार एफवाईएम @ १० टन प्रति हेक्टर + १००:५०:५० किग्रा / हेक्टेयर एनपीके उपज के लिए बेहतर प्रदर्शन करता है। भारतीय पालक में अधिकतम ५० × ३० सेमी की दूरी पर। इस प्रकार, कोंकण कृषि-जलवायु स्थिति के तहत भारतीय पालक में उपज को अधिकतम करने के लिए पोषक तत्व प्रबंधन के प्रति एकीकृत दृष्टिकोण आवश्यक है। हालाँकि, इसे लगातार दो वर्षों के लिए एक ही क्षेत्र की जाँच करके पुष्टि की आवश्यकता है।

CHAPTER I

INTRODUCTION

Vegetables represent an excellent component of the habitual diet in the world. They are ecumenically appreciated because they are not only supply the protective nutrients and integrate variety to a monotonous diet, but additionally have an alternative taste, gratifying appearance and aroma.

A world vegetable survey specified that around 392 vegetable crops are cultivated in virtually 200 countries all over the world and most of the vegetables are marketed freshly with only a scantilla processed. Virtually three-fourths of the world's production of vegetables occurs in Asia, mostly in China, which produces over a moiety of the world's vegetables. The area of world land devoted to vegetables has been incrementing due to the potential income value from vegetables. India is the second most immense producer of vegetable in the world next to china with the annual production of 184 million tons from an area of 10.25 million hectare and productivity is 17.97 metric tons per hectare and contributes 20 per cent of the world vegetable production (Anon, 2018). Indian Council of Medical Research, New Delhi recommends intake of 125g leafy vegetables, 100g roots and 75g other vegetables/ day / capita for a balanced diet. Further, the medical council of India informs the vegetable production is much inadequate than the requirement. If balanced diet is provided to every individual; the production of vegetables needs to be raised to 250 million tons by 2024-2025. To achieve productivity of vegetables needs to be increased. Rational and efficacious exploration of sustainable plant resources is a paramount task for ascertaining ecumenical aliment security for the future.

Amongst all the vegetables, the leafy vegetables have high protective nutritional value. They are opulent in minerals and hence can be called as “mines of minerals”. They provide vitamins specially A and C, minerals, carbohydrates, fat, fibres, amino acid, oxalic acid, adipose acid, folic acid, antioxidants, carotenoids, calories and appreciable quality of proteins (Pandita and Lal, 1998; Raju *et al.*, 2007; Gupta and Prakash, 2011) and soft fibrous matter provides compulsory roughage in diet. Besides their alimental superiority, their commercial cultivation is withal remunerative. Most of the leafy vegetables *viz.*, Amaranth, spinach, radish, fenugreek and coriander etc. are characterized by production cycle and crop for vegetable purpose can be harvested within 20 to 40 days.

Indian spinach (*Basella rubra* L.) commonly known as poi, mayalu, belongs to the family Basellaceae which is also popular as summer leafy vegetable. It is also known as Malabar, Ceylon, East-Indian, Surinam and Chinese spinach (Facciola, 1990). Indian spinach is a fleshy, twining much branched herb with alternate leaves. Leaves are broadly ovate and pointed at the apex. Flowers are white or pink, small sessile in cluster on elongated thickened peduncles in an open branched inflorescence. Fruit is enclosed in fleshy perianth. It is fast growing perennial plant, however, cultivated as an annual for home gardens and as a cash crop to some extent. It is an easy growing plant propagated by seed, root or long tip cuttings. *B. rubra* is commonly grown for its leaves and young shoots, which are high in Vitamin A, B9, C, iron and calcium (Grubben and Denton, 2004).

The cultivation of *Basella* requires opportune supply of plant nutrient. This requisite can be provided by applying inorganic fertilizer or organic manure or both. Only organic manure such as cattle and chicken waste, and other bulky, natural substances

application can supersede the requisite of inorganic fertilizer. Organic manure ameliorates soil structure as well as increases its water holding capacity moreover it promotes biological activity in the soil, as well as a favorable nutrient exchange capacity, water balance, organic matter content and soil structure. Recently, organic farming is appreciated by vegetable consumers as it enhances quality of the produce.

In vegetables, spacing is a non-monetary input, but it plays a vital role by transmuting the magnitude of competition. There is a desideratum to manipulate the row spacing to minimize competition and to increment the plant productivity especially in leafy vegetables. The competitive facility of a plant depends greatly upon the density of plants per unit area and soil fertility status. Uniform distribution of crop plants over an area results in efficient use of nutrients, moisture, and suppression of weeds leading to high yield. In wider row spacing, solar radiation falling within the rows gets wasted particularly during the early stages of crop growth, whereas in closer row spacing upper part of the crop canopy may be well above the light saturation capacity but the lower leaves remain starved of light and contribute negatively towards yield. Thus, optimum row spacing are necessary for interception of sunlight to each strata of leaves. This will enhance the rate of photosynthesis and consequently, the dry matter production which can ultimately increase the crop yield. Establishment of optimum plant population by maintaining proper row spacing is one of the important factors to secure a better translocation of photosynthates, which render better yield of crop.

Looking towards the agriculture belonging to *Konkan* conditions, the average land holding of farmers are minutely diminutive and majority of farmers are marginal farmers. Moreover, the available land is again scattered and are having scanty

irrigation back up which is conventionally available up to January to February, afterwards the availability of irrigation water for growing crops. Considering all these constraints; farmer has to adopt intensive reiterated cultivation. Additionally, considering the *Konkan* climatic conditions, leafy vegetables are integral part of their balanced diet. Due to high rainfall during June – September it is not possible to grow the traditional vegetables like amaranth, fenugreek etc. However, *Basella* can sustain in high rainfall conditions prevailing in Konkan region and by contemplating its ability to sustain the high rainfall, humidity coupled with its nutritional richness; it can be a superior alternative vegetable for its commercial cultivation. The protocol required for its commercial cultivation *viz.*, spacing, manures and fertilizers *etc.* have not yet been studied.

Hence, the present investigations entitled effect of spacing and organic manures on growth and yield performance of Indian spinach has been planned and executed with following objectives:

1. To study the effect of spacing on growth and yield of Indian spinach
2. To study the effect of different levels of organic manure on growth and yield of Indian spinach
3. To find out the optimum spacing and organic manure for maximization of yield of Indian spinach

CHAPTER - II

REVIEW OF LITERATURE

During present investigation entitled “effect of spacing and organic manure on growth and yield performance of Indian spinach (*Basella rubra* L.).” Indian spinach is one of the important summer leafy vegetable in India and in many other countries of the world. The crop has drawn less attention of the researchers because normally it grows without care or management practices. For that a very few studies on growth, yield and development aspects of *Basella* have been carried out in our country as well as in many other countries of the world.

The research work so far done in India is not adequate. Hence, efforts have made to review the literature on the effect of spacing and manure on growth and yield of various leafy vegetables crops in India along with *Basella* in India as well as in other countries have been reviewed in this chapter under the following heading and subheading as follows.

2.1 **Growth Characters:**

2.1.1. **Effect of spacing:**

Mortley *et al.* (1992) studied that the effect of row spacing on growth and yield of vegetable amaranth (*Amaranthus spp.*) and they revealed that stem diameter was increased linearly from 10 to 40 cm and the maximum was recorded at a spacing of 40 cm.

Peiretti and Gesumaria (1998) conducted an experiment using inter row spacing on growth and yield of amaranth with four different row spacing and the approximate

densities were 1,00,000, 7,40,000, 5,50,000 and 4,70,000 plants/ha. The vegetative characters and yield per plant at harvest decreased with closer row spacing, particularly at 0.30 m spacing.

Malligawad and Patil (2001) studied the effect of plant density and planting geometry on growth and yield of grain amaranth. They observed that the highest plant height (148.2 cm) in row spacing of 60 × 30 cm and the lowest plant height (133.6 cm) in spacing of 30 × 30 cm.

Sharma *et al.* (2001) with six different plant geometries viz., 40 × 36 cm, 60 × 24 cm, 40 × 45 cm, 60 × 30 cm, 50 × 48 cm and 60 × 40 cm. They revealed that the longer plants were obtained with closer spacing while; higher number of branches per plant was obtained with wider spacing.

Kuwar *et al.* (2003) conducted a field experiment to determine the optimum spacing and plant density for okra cultivars AKOV-97-16, Parbhani Kranti and Arka Anamika. The spacing comprised of 60 × 30, 60 × 22.5, 45 × 45 and 45 × 30 cm. They assessed that among spacing, 45 × 45 cm had the highest number of branches (4.58) and 45 × 30 cm spacing had the highest plant height (90.11 cm).

Choudhary *et al.* (2004) reported that growth parameter like number of leaves per plant (17.38) and leaf area (600 cm²) per plant at 90 DAS were found maximum low plant densities due to wider sown plants get ample sunlight free aeration and wide space for spreading in palak.

Okut and Yidirim (2005) performed study on the effect of different row spacing and nitrogen doses on certain

agronomical characteristics of coriander (*Coriandrum sativum* L.). It was revealed that the highest plant height (37.89 cm) was recorded in 30 cm row spacing, whereas the lowest (35.38 cm) was in 20 cm row spacing.

Majumder (2007) revealed that in stem amaranth the highest (90.68 cm) stem length was recorded from S₃ *i.e.* (30 × 40 cm) and the lowest (86.71 cm) was from recorded from S₁ *i.e.* (30 × 20 cm) and the maximum (21.55 mm) stem diameter was recorded from S₃ and the minimum (18.31 mm) was from recorded from S₁.

Manikandan and Srimathi (2007) evaluated the effect of spacing and fertilizer on seed yield and grain quality of amaranth. Results revealed that the wider spacing (45 × 20 cm) recorded 2-4 per cent more plant height as compared to closer spacing. The highest plant height was 157 cm in 45 × 20 cm spacing and lowest plant height was 133 cm in 45 × 10 cm spacing.

Vasmate *et al.* (2008) conducted an experiment on the effect of spacing and organic manure on seed yield of coriander (*Coriandrum sativum* L.) was carried out during rabi season of 2003-04 at Department of Horticulture, M.A.U., Parbhani. Amongst different spacing, the treatment S₁ (30 × 20 cm) recorded maximum number of leaves per plant and height per plant.

Chaudhari *et al.* (2009) studied the effect of varying row spacing and sowing dates on yield attributes of rabi grain amaranth under south Gujarat condition. The highest number of

branches per plant (15.0) were recorded in spacing of 50 × 50 cm.

Joseph *et al.* (2009) studied the effect of intra-row spacing and phosphorus fertilizer on growth and grain yield of amaranth. Their results showed that the highest plant height (139.67 cm) was recorded in 30 × 50 cm spacing while, the lowest (133.30 cm) was in 50 × 50 cm spacing, whereas the highest diameter (2.05 cm) was recorded in 50 × 50 cm spacing which was significantly higher than the other spacing.

Parvin *et al.* (2009) observed that maximum plant height 40 DAS (62.68 cm), number of leaves per plant (38.08) and stem diameter (2.23 cm) were found in low plant density (1, 66, 666 plants per hectare) and the minimum values were found in plant density (3, 33, 333 plants per hectare) in amaranth (*Amaranthus lividus* L.).

Kumar *et al.* (2011) evaluated the effect of row spacing and fertilizer on growth and yield attributes of okra *cv.* Nirmal-20 at Basar. The results indicated that the sole effect of spacing on plant height was significant. The maximum plant height (361.10 cm), inter nodal length (29.87 cm) and number of leaves (56.3) were noted in wider intra row spacing of 30 cm.

Smitha *et al.* (2011) recorded the highest number of leaves (39.52 plants per hectare) and leaf area (62.00 cm² plants per hectare) in amaranth genotype with the row spacing 45 cm compared to the closer row spacing of 30 cm.

Patel *et al.* (2011) conducted an experiment on effect of row spacing and seed rate on growth, forage productivity and economics of amaranth genotype during *kharif*. The results of

their study showed that the row spacing of 30 cm recorded significantly the highest plant height as compared to other spacing.

Abothula (2012) observed that the maximum leaf area and maximum number of branches per plant were recorded with the low plant density however, the lower number of branches and leaf area per plant was recorded with high plant density in amaranth. (*Amaranthus tricolor* L.)

Nayak *et al.* (2013) studied that the 30 × 10 cm spacing produced significantly higher plant height whereas 30 × 15 cm spacing produced higher number of branches per plant of coriander.

Sharma *et al.* (2013) conducted an experiment on influence of plant density and nutrient management on growth, yield and quality of radish (*Raphanus sativus* L.) cv. “Pusa Chetki”. The results revealed that wider spacing (30 × 15 cm) recorded significantly higher number of leaves (13.96) and leaf area (203.99 cm²) as compared to closer spacing.

Bairagi (2014) studied the effect of different doses of phosphorus and row spacing on the yield and quality of fenugreek (*Trigonella foenum graecum* L.) seed. It was reported that highest plant height (43.5 cm) which was observed in S₄ (40 cm row spacing), while the lowest (40 cm) was in S₂ (20 cm line sowing).

Islam *et al.* (2014) observed that highest plant height (34.48 cm) was recorded from treatment S₃ (50 cm × 50 cm) and the lowest plant height (30.45 cm) was recorded from treatment S₁ (50 × 30 cm). The maximum (6.25) number of branches per

plant was found from S₃, the minimum (5.58) from S₁. Plant spacing S₃ gave the maximum (40.58) number of leaves per plant and minimum (35.55) were recorded from S₁ in Indian spinach.

Madisa *et al.* (2015) conducted study on effect of plant spacing on the growth and yield components of okra in Botswana. They observed that the intra-row spacing of 90 cm gave the highest stem diameter (3.1 cm) and the lowest (2.6 cm) was in 30 cm intra-row spacing.

Chavan (2016) studied the effect of spacing and clipping on growth and seed yield of amaranth (*Amaranthus tricolor* L.) cv. Konkan Durangi under Konkan agro-climatic condition and reported that the treatment S₃ (40 cm line sowing) showed the highest plant height (107.13 cm) and stalk diameter (1.47 cm). The lowest plant height (93.87 cm) and stalk diameter (0.78 cm) was reported in treatment S₁ (20 cm line sowing).

Falodun and Ogedegb (2016) studied on the effect of planting, spacing and harvest intervals on growth, yield and quality of okra (*Abelmoschus esculentus* (L.) Moench). They revealed the highest plant height (22.19 cm), stem diameter (0.60 cm) at the 40 × 30 cm and highest number of leaves (9.74) at 60 × 30 cm spacing.

Lavanya *et al.* (2017) reported that closer spacing (45 × 10 cm) resulted in maximum plant height whereas all other vegetative parameters like number of leaves and leaf area were found maximum with wider spacing (45 × 30 cm).

Pawar (2017) studied the effect of spacing and clipping on herbage and seed yield of amaranth (*Amaranthus tricolor* L.) cv. Konkan Durangi under Konkan agro-climatic condition and

reported that the treatment S₄ (40 cm line sowing) showed the highest plant height (89.59 cm) and highest stalk diameter (0.81 cm). The lowest plant height (83.48 cm) and stalk diameter (0.72 cm) were reported in treatment S₁ (10 cm line sowing).

Chormule and Patel (2017) reported that wider spacing of 60 × 45 cm recorded significantly the maximum values for growth parameters *viz.*, plant height (64.72, 64.75 and 64.74 cm), stem diameter (1.54, 1.39 and 1.47 cm) and number of branches per plant (1.60, 1.87 and 1.73) in okra.

Toungos *et al.* (2018) studied the effect of nitrogen fertilizer and row spacing on the growth of amaranth. It was evident from the results that stem girth of amaranth increased significantly as row spacing increased but leaf area index increased as row spacing decreased. The 40 cm inter-row spacing was found as best for the production of amaranth.

Lesi (2018) reported that in okra the wider plant spacing (50 × 50 cm) significantly ($p < 0.05$) increased stem diameter (2.1 and 2.0 mm), number of leaves (18.1 and 18.3) than the closest plant spacing (50 × 30 cm) in 2016 and 2017.

2.1.2 **Effect of organic manure:**

Sorin and Tanaka (1991) reported that increase in seedling growth of spinach by application of organic manure provided that an interval of several weeks is recommended between application of organic manure and cultivation of spinach.

Sagaya and Gunthilagaraj (1996) reported that seed germination, plant height of amaranth were more in beds applied with vermicompost.

Vadiraj *et al.* (1996) reported that graded levels of vermicompost (5, 10, 15, 20 and 25 t/ha) application increased germination percentage, growth, of coriander cv. Rcr-41, Bulgarian and local, as compared to control.

Palada *et al.* (1999) conducted field experiment to determine growth and yield response of Malabar spinach (*Basella alba* L.) to various levels of cow manure application. Dehydrated cow manure (2 % N, 1 % P, 2 % K) was soil-incorporated before planting at rates of 0, 10, 20, and 40 t/ha. Results indicated that highest stem length (107.9 cm) was found in treatment cow manure applied @ 20 t/ha.

Vasmate *et al.* (2008) performed an experiment on the effect of spacing and organic manure on seed yield of coriander (*Coriandrum sativum* L.) was carried out during rabi season of 2003-04 at Department of Horticulture, M.A.U., Parbhani. Among the organic manures M₁ (FYM @ 20 tonnes per hectare) recorded maximum height per plant, number of leaves per plant in coriander.

Akparobi (2009) studied the effect of different level of farmyard manures (0 t/ha, 15 t/ha, 25 t/ha and 35 t/ha) on the growth and yield of *Amaranthus cruentus*. Results showed that all parameters measured increased with increased more manure to the seedlings had positive effect on all the parameters measured. The seedlings treated with manure level of 35 t/ha had the highest mean values of 123.27 cm, 11 585 cm², 141.56,

1.75 kg and 0.99 kg per plant for plant height, leaf area, number of leaves, fresh and dry weights respectively while those treated with manure at 0 t/ha had the least values for the parameters measured.

Padmanabha *et al.* (2009) conducted field experiment at horticulture research farm, University of Agricultural Science, Bangalore during *rabi* season of 2002. The results revealed that application of 150:100:100 kg/ha NPK+ agrimagic equivalent to FYM on N basis gave significantly higher plant height, number of leaves and leaf area per plant in palak.

Gunjal (2010) revealed that application of (RDF *i.e.* 60:40:0 NPK kg/ha) + 10 ton FYM + 60 kg K₂O per ha recorded significantly higher plant height, number of leaves in grain amaranth (*Amaranthus hypochondriacus* L.)

Kushare *et al.* (2010) revealed that seed yield, growth and yield attributes of *Rabi* grain amaranth (*Amaranthus hypochondriacus* L.) were significantly increased by the application of 40:40:40 NPK/ha and FYM @ 10 t/ ha. Significantly the highest plant height (127.83 cm), number of leaves per plant (29.82) stem girth (3.65 cm), was recorded with the application of FYM @ 10 t /ha over control.

Umesha *et al.* (2011) conducted the experiment to find out the effect of different organic manure on growth, yield and quality of makoi (*Solanum nigrum* L.). They revealed that maximum plant height, number of branches per plant, plant spread, number of leaves per plant, leaf area were recorded with the application of FYM 20 t + vermicompost 1.0 t + neem cake

1.0 t /ha. Fresh and dry herbage yield were also maximum with the same treatment.

Miah *et al.* (2013) conducted experiment at the farm of BSMRAU campus, Gazipur during February-April, 2007 in a randomized complete block design (RCBD). Treatments were control and seven nitrogen sources namely, urea (107 kg N/ha), cow dung (23.75 t/ha), poultry manure (9.3 t/ha), half cow dung and half urea, half poultry manure and half urea, three fourth cow dung and one fourth urea and three fourth poultry manure and one fourth urea, respectively with four replications ensuring the 107 kg N/ha supply from all sources of nitrogen used. Compared with cow dung and poultry manure, urea (107 kg N/ha) resulted in higher plant height (85.07 cm), and stem diameter (21.63 mm).

Nayak *et al.* (2013) studied that the application of FYM @ 20 t/ha produced significantly higher plant height and number of branches per plant of coriander.

Hisham *et al.* (2014) observed that maximum plant height (127.6 cm), number of leaves was (49.35), number of branches (2.80) in the treatment (variety OH-2324 and 25 t/ha FYM).

Okoli and Nweke (2015) stated that the effect of poultry droppings (0 t/ha, 5 t/ha, 10 t/ha, 15 t/ha and 20 t/ha) was studied. Results obtained from the study showed no significant ($P=0.05$) difference among the higher rates of poultry manure (10 t/ha, 15 t/ha, and 20 t/ha), but significantly performed competitively better than the lower rates of 5 t/ha and 0 t/ha, in most of the parameters assessed. The growth and yield parameters measured increased with increasing rate of the

poultry manure applied. The plants treated with 20 t/ha rate of poultry manure recorded the highest value in all the parameters studied. Thus for maximum increase production of amaranth in the studied area, 20 t/ha of poultry manure should be used.

Sanni (2016) studied the effect of compost, cow dung and 15:15:15 kg NPK /ha fertilizer on growth and yield performance of amaranth (*Amaranthus hybridus*). The obtained results indicated that all treatments significantly achieved an increment in morphological parameters (numbers of leaves, stem girth, leaf area and plant height) and fresh weight yield comparing with the control. The best results in terms of these characters were obtained in the following order cow dung > compost > NPK and control.

Ahmad *et al.* (2017) concluded that the highest number of leaves per branch (6.24) and highest leaf area (14.95 cm²) was recorded in coriander plants received poultry manure 0.8 kg/m².

Jabeen *et al.* (2017) results revealed that growth parameters like plant height (27.18, 27.44 and 27.48 cm) and leaf area (20.10, 64.10 and 104.30 cm²) were highest in the treatment in which vermicompost @ 3 tonnes / ha + biofertilizers @ 5 kg /ha was applied in spinach beet (*Beta vulgaris var. bengalensis*).

Miglani *et al.* (2017) conducted an experiment on the influence of different organic manures on the growth and yield of okra. The result obtained from the experiment showed that the digested FYM 20 t/ha recorded the maximum plant height and number of branches, *i.e.* 131.64 cm and 2.54 respectively.

Ullah *et al.* (2017) studied the influence of organic manure on growth and yield of lettuce cultivars (local and chinese cultivar). The maximum number of leaves plant (19.5) and plant height (26.66 cm), was recorded in lettuce plant treated with poultry manure (10 t/ha).

Barau *et al.* (2018) conducted field experiment in 2010 at the Institute for Agricultural Research Farm, Samaru, Nigeria. Results indicated that plant height (25.69 cm), shoot fresh weight (20.57 g/plant) and number of leaves (25.69) and branches per plant (270) were significantly ($P < 0.05$) higher with the application of 8 t/ha of poultry manure compared with no manure than the other treatments.

Khatun *et al.* (2018) conducted pot experiment to investigate the effect of vermicompost and chemical fertilizer on the growth of yield and nutrient content of *Ipomoea aquatic* and *Basella alba* during the period of 14th May to 13th July, 2013. The experiment was laid to fit a completely randomized design (CRD) with three treatments [control (T_0), vermicompost (T_1) and chemical fertilizer (T_2)] each having three replications for each plant. Yield contributing characters like plant height, stem length, rooting depth, number of leaves, fresh weight and dry weight were significantly ($P < 0.05$) influenced by different (vermicompost and chemical fertilizer) treatments. From the experiments it has been observed that the effect of vermicompost and chemical fertilizer on the growth of yield and nutrient content of *Ipomoea aquatic* and *Basella alba* were $T_1 > T_2 > T_0$ and $T_1 > T_0 > T_2$, respectively. The highest yield of *Ipomoea aquatic* and *Basella alba* (16.65 g/plant and 34.72 g/plant respectively) was

found for the vermicompost treatment (T₁) due to the nutrient availability of the soil.

Altaf *et al.* (2019) revealed that the plant height at harvesting and number of branches per plant of chilli increased significantly with T₉ treatment (100:50:50 kg NPK/ha + FYM @ 8 ton per hectare).

2.2 Yield characters:

2.2.1 Effect of spacing:

Gadakh *et al.* (1990) carried out a field experiment to study the effect of different levels of spacing (30 × 5, 30 × 10, 30 × 15 and 30 × 30 cm) on growth and yield of okra at Rahuri during 1986-87 with two cultivars Pusa Sawani and Sel-2-2. Significantly higher pod yield of both the varieties were obtained when they were sown at closer spacing of 30 × 5 cm as compared to rest of the wider spacing.

Norman and Shongwe (1993) reported that in amaranth the high plant density (49,382 plants per hectare) produced the minimum total yield per plant and gave the highest total yield per hectare whereas the converse was observed with the low plant density (12,335 plants per hectare)

Peiretti and Gesumaria (1998) conducted an experiment using inter row spacing on growth and yield of amaranth with four different row spacing and the approximate densities were 1,00,000, 7,40,000, 5,50,000 and 4,70,000 plants per ha. The vegetative characters and yield per plant at harvest decreased with closer row spacing, particularly at 0.30 m spacing.

Naik and Singh (1999) obtained the highest yields (126.4 q/ha) from plants grown at the closest spacing of 90 × 15 cm as compared to 90 × 20 cm or 90 × 25 cm in okra.

Missinga and Currie (2002) conducted an experiment to assess the impact of plant densities of amaranth on yield and yield contributing characters and reported that spacing did not affect the individual plant yield but yield per hectare was greatly affected by plant spacing.

Ahbasdokht *et al.* (2003) conducted an experiment to determine the effect of crop densities (10, 20 and 40 plants m²) of amaranth in Iran. Yield and yield contributing characters were statistically significant in different density. The density with 40 plants gave the minimum yield, whereas 10 plants gave the highest single plant yield but lowest yield was found when yield in hectare was considered.

Choudhary *et al.* (2004) recorded that the green yield per plant of palak was found increase with decreased in plant density. In contrast the green per hectare increase with increase in plant density as more number of plants can be accomanded per unit area of land in high density which ultimately resulted in more green yield rather than low dense ones.

Moore *et al.* (2004) carried out an experiment to determine the effects of spacing on the harvesting and yield of stem amaranth with 6, 9, 12 and 18 plants per 5 m or row. In the competition experiments it was observed that the yield increased up to a certain level, then decrease. In highest spacing per plant yield was increased up to a certain level but the total yield per hectare decreased.

Talukder *et al.* (2005) reported that maximum green yield per plant was produced from low plant density (1, 11, 111 plants per ha) at all three stages of harvesting in amaranth (*Amaranthus tricolor* L.)

Mane *et al.* (2008) conducted experiment with three spacing (15, 30 and 45 cm plant to plant) and four cuttings (no cutting, one cutting, two cuttings and three cuttings). Spacing 15 cm plant to plant gave the highest green yield per hectare (108.07 q). Spacing S₃ gave highest green yield per plant (39.10 g). Whereas cutting C₃ gave highest green yield per plant (67 and 92 g per ha). As regards seed yield spacing S₁ gave highest seed yield per ha. (19.02 q). The spacing S₃ gave highest seed yield per plant (5.92 g). The interaction effect C₃ S₁ gave the highest green yield per ha. (197.88 q). Whereas C₁S₁ gave highest seed yield per ha. (20.17 q). Thus, 15 cm plant to plant spacing was superior for obtaining green yield as well as seed yield of palak per hectare.

Parvin *et al.* (2009) observed the maximum yield (77.94 t/ha) of amaranth of high density (3, 33, 333 plants/ha) and the minimum (56.33 t/ha) was in row density (1, 66, 666 plants/ha).

Islam *et al.* (2014) studied the effect of different plant spacing on the growth and yield of Indian spinach. Plant spacing S₃ (50 cm × 50 cm) gave the maximum fresh weight of leaves (61.47 g), stem per plant (71.48 g) and fresh weight of plant (132.95 g) while, the minimum fresh weight of leaves (52.42 g), stem (64.05 g) per plant and fresh weight (116.47 g) of plant were recorded from S₁ in Indian spinach.

Lesi (2018) reported that in okra the widest plant spacing (50 × 50 cm) significantly ($p < 0.05$) increased number of fruits per plant (20.9 and 20.3), fruit weight (20.32 g and 31.24 g) and fresh fruit yield per plant (424.7 g and 431.2 g) than the closest plant spacing (50 × 30 cm) in 2016 and 2017.

2.2.2 **Effect of organic manure:**

Cavazza and Bianco (1975) reported that inorganic fertilizers combined with organic fertilizers like FYM and composted town refuse after sowing or transplanting to the crops *viz.*, radish, swiss chard, spinach cauliflower and lettuce resulted in the highest yields.

Will (1978) observed that spinach and lettuce responded best to the organic fertilizers like compost, FYM etc. He further stated that the use of both, organic and inorganic fertilizers gave the highest yields with spinach, lettuce and chinese cabbage.

Jambhekar (1996) studied the effect of vermicompost on short duration crops like radish, spinach and green peas. She observed that yield was high in plots receiving vermicompost (100%, 50% and 75 % with recommended dose of NPK) as compared to 100% recommended dose of NPK through inorganic fertilizers. Half of the recommended dose of NPK through chemical fertilizers and the rest through vermicompost was found to be the best treatment having larger leaf area, attractive colour and luster of leaves. She also stated that there was a considerable saving of chemical fertilizers in short duration crops.

Sagaya and Gunthilagaraj (1996) reported that seed germination, plant height, fresh weight and yield of amaranth were more in beds applied with vermicompost.

Vadiraj *et al.* (1996) reported that graded levels of vermicompost (5, 10, 15, 20, 25 t/ha) application increased germination percentage, growth, herbage and seed yield of coriander cv. Rcr-41, Bulgarian and local, as compared to control.

Palada *et al.* (1999) revealed that edible leaf fresh yield (194.00 g/plant) and gross yield (53.95 t/ha) was found highest in treatment T₂ (Urea). They suggested that cow dung and poultry manure appeared to be compatible to urea for stem amaranth cultivation in terms of fresh weight and gross yield.

Sannigrahi and Borah (2001) revealed that in lady's finger the application of 20 t/ha FYM supplemented with 50% recommended dose of chemical fertilizer *i.e.* 30 kg N, 13.2 kg P and 16.6 kg K per hectare gave highest yield (46.3 q/ha) as compared to 100% NPK alone. The combination of 25% NPK with 20 t/ha FYM gave almost equal yield compared with 100% NPK.

Padmanabha *et al.* (2009) conducted field experiment at horticulture research farm, University of Agricultural Sciences, Bangalore during *rabi* season of 2002. The research results revealed that application of 150:100:100 kg NPK/ha + agrimagic equivalent to FYM on nitrogen basis gave significantly higher green leaf yield of palak (157.2 q/ha), ratoon- I (143.8 q/ha) and ratoon II (131.5 q/ha).

Premsekhar and Rajashree (2009) reported that the field experiment were conducted to study the influence of

different organic manure on the growth, yield and quality of okra var. Arka Anamika. The experiments were conducted in a randomized block design replicated thrice with eleven treatments involving different organic manures along with no manure control. The results showed that FYM 20 t/ha recorded the highest yield of 10.39 t/ha.

Gunjal (2010) revealed that application of (RDF *i.e.* 60:40:0 NPK kg/ha) + 10 ton FYM + 60 kg K₂O per ha recorded significantly higher plant height, number of leaves, total dry matter, yield (1700 kg/ha) and yield components in grain amaranth (*Amaranthus hypochondriacus* L.)

Kushare *et al.* (2010) revealed that seed yield, growth and yield attributes of *Rabi* grain amaranth (*Amaranthus hypochondriacus* L.). were significantly increased by the application of 40:40:40 NPK/ha and FYM @ 10 t/ha. Significantly the highest number of spikelet per spike (52.89) and seed yield (1516.67 kg/ha) was recorded with the application of FYM @ 10 t/ha over control.

Umesha *et al.* (2011) conducted the experiment to find out the effect of different organic manure on growth, yield and quality of makoi (*Solonom nigrum* L.). They revealed that maximum fresh and dry herbage yield were recorded with the application of FYM 20 t + vermicompost 1.0 t + neem cake 1.0 t/ha.

Miah *et al.* (2013) conducted experiment at the farm of BSMRAU campus, Gazipur during February-April, 2007 in a randomized complete block design (RCBD). Treatments were control and seven nitrogen sources *viz.*, urea (107 kg N/ha), cow

dung (23.75 t/ha), poultry manure (9.3 t/ha), half cow dung and half urea, half poultry manure and half urea, three fourth cow dung and one fourth urea and three fourth poultry manure and one fourth urea, respectively with four replications ensuring the 107 kg N/ha supply from all sources of nitrogen used. Compared with cow dung and poultry manure, urea resulted in higher fresh weight of plant, stem and leaf accompanied with maximum gross yield. However, data on the studied parameters varied significantly ($p < 0.05$). So cow dung and poultry manure applied at 23.75 t/ha and 9.3 t/ha, respectively were compatible to urea as nitrogen source for stem amaranth production.

Salami and Babajidei (2015) conducted field experiment at Department of Agricultural Education, Emmanuel Alayande College of Education, Oyo, Nigeria. Study focused on to assess the effects of poultry manure rates (0.0, 1.0, 2.0, 3.0 and 4.0 tons/ ha on growth and shoot yield of *Basella alba*. Application of poultry manure at 3.0 tons/ ha and weekly harvesting significantly enhanced growth and cumulative shoot yield (177.40 g/plant), and are therefore recommended for *Basella alba* production in the study area.

Sanni (2016) studied the effect of compost, cow dung and NPK 15:15:15 fertilizer on growth and yield performance of amaranth (*Amaranthus hybridus*). The obtained results indicated that all treatments significantly achieved an increment in fresh weight yield comparing with the control. The best results in terms of yield attributing characters were obtained in the following order cow dung > compost > NPK 15:15:15 kg/ha and control.

Miglani *et al.* (2017) conducted an experiment on the influence of different organic manures on the growth and yield of okra. The result obtained from the experiment showed that the digested FYM 20 t/ha recorded the maximum yield (5.12 t/ha).

Ullah *et al.* (2017) studied the influence of organic manure on growth and yield of lettuce cultivars (local and Chinese cultivar). Maximum total yield (4.16 t/ha) was recorded in lettuce plant treated with poultry manure (10 t/ha).

Barau *et al.* (2018) conducted a field experiment in 2010 at Institute for Agricultural Research Farm, Samaru, Nigeria. Study focused on to assess the effects of poultry manure rates (0, 4, 8 and 12 t/ha) and seedling age (2, 3 and 4 weeks after sowing) at transplanting on growth and yield of amaranth (*Amaranthus caudatus* L.). Study suggested that marketable yield increased significantly with increasing poultry manure (4 t/ha) with transplanting age (2-3 weeks) after emergence to benefit farmers the highest.

Khatun *et al.* (2018) conducted pot experiment to investigate the effect of vermicompost and chemical fertilizer on the yield and nutrient content of *Ipomoea aquatic* and *Basella alba* during the period of 14th May to 13th July, 2013. The experiment was laid to fit a completely randomized design (CRD) with three treatments [control (T₀), vermicompost (T₁) and chemical fertilizer (T₂)] each having three replications for each plant. They revealed that highest yield of *Ipomoea aquatic* and *Basella alba* (16.65 g/plant and 34.72 g/plant respectively) was found for the vermicompost treatment i.e. (T₁) due to the nutrient availability of the soil.

Altaf *et al.* (2019) stated that the highest yield (954.54 kg/ha) was recorded with T₉ treatment (100:50:50 kg NPK + FYM @ 8 ton/ ha) in chilli (*Capsicum annum*).

Hashimi *et al.* (2019) conducted a pot experiment at the research farm, Shaikh Zayed University, Khost, Afghanistan to examine the production of spinach (*Spinacia oleracea* L.) and soil properties under varying levels of cow manure, inorganic fertilizer and cow manure + inorganic fertilizers. They suggested that cow manure with applied nitrogen application can be a valuable practice for increasing yield and available nutrients in soil.

2.3 Chemical parameters:

2.3.1 Effect of spacing:

Spaldon (1968) observed reduction in row spacing encouraged upright growth but did not affect vitamin C content of spinach.

Seif and Ali (2003) conducted an experiment to study the effects of in-row spacing at 20, 40 and 60 cm on yield and some quality attributes of tomato. It was reported that quality aspects were not significantly affected by the plant spacing.

Nayak *et al.* (2013) studied that the 30 × 10 cm spacing produced significantly higher dry matter accumulation of coriander.

Islam *et al.* (2014) observed that the maximum dry matter content (15.00 %) was recorded from S₃ (50 × 50 cm) and the minimum (11.89 %) from S₁ (50 × 30 cm) in Indian spinach.

Majumder (2007) revealed that the maximum (6.00 %) dry matter content of leaves per plant of stem amaranth was recorded from S₃ (30 × 40 cm) and the minimum (5.42 %) was from recorded from S₁ (30 × 20 cm).

Parvin *et al.* 2009) observed that maximum dry matter of stem (6.07 %), dry matter of leaf (6.69 %) and dry matter of root (7.02 %) were found in low plant density (1, 66, 666 plants/ha) and the minimum value were found in the high plant density (3, 33, 333 plants/ha) in amaranth (*Amaranthus lividis* L.)

Smitha *et al.* (2011) recorded the highest total dry matter accumulation (62.55 g per plant) in amaranth genotypes with the row spacing of 45 cm compared to the closure row spacing of 30 cm.

Chavan (2016) reported that the different spacing showed non-significant effect on dry matter content of amaranth. It was observed that the highest dry matter (66.71 g) was recorded in S₂ (30 cm line spacing) followed by S₄ (broadcasting) while, the lowest (64.91) was in S₁ (20 cm line sowing).

Pawar (2017) studied the effect of spacing and clipping on herbage and seed yield of amaranth (*Amaranthus tricolor* L.) *cv.* Konkan Durangi under Konkan agro-climatic condition and reported that the different spacing showed non-significant effect on dry matter content of plant. The highest dry matter (69.03 g) was recorded in S₄ (40 cm line spacing) while, the lowest (53.97 g) was in S₁ (10 cm line sowing).

Prasanna (2019) studied the effect of consecutive sowings and spacing on growth and yield of amaranth, radish

and spinach and revealed that spacing does not showed any significant effect on ascorbic acid content in amaranth, radish and spinach.

2.3.2 **Effect of organic manure:**

Padmanabha *et al.* (2009) conducted a field experiment at horticulture research farm, University of Agricultural Sciences, Bangalore during *rabi* season of 2002. The research results revealed that application of 150:100:100 kg/ha NPK + agrimagic equivalent to FYM on nitrogen basis gave significantly higher total dry matter production per plant (2.36 g) in palak.

Kushare *et al.* (2010) revealed that seed yield, growth and yield attributes of *Rabi* grain amaranth (*Amaranthus hypochondriacus* L.) were significantly increased by the application of 40:40:40 kg NPK/ha and FYM @ 10 t/ha. Significantly the highest dry matter accumulation (82.51 g) was recorded with the application of FYM @ 10 t/ ha over control.

Umesha *et al.* (2011) conducted the experiment to find out the effect of different organic manure on growth, yield and quality of makoi (*Solonom nigrum* L.). They revealed that maximum total dry matter accumulation were recorded with the application of FYM 20 t + vermicompost 1.0 t + neem cake 1.0 t/ ha.

Nayak *et al.* (2013) studied that the application of FYM @ 20 t/ha produced significantly higher dry matter (32.81 q/ha) accumulation of coriander.

Hisham *et al.* (2014) observed that maximum ascorbic acid (15.58 mg/100g) in the treatment (variety OH-2324 and 25 t/ha FYM).

Roni *et al.* (2014) conducted field experiment on “effect of plant spacing and nitrogen levels on nutritional quality of Broccoli.” Results revealed that the highest ascorbic acid content (50.38 mg/100 g) was obtained from spacing 60 × 30 cm and the highest beta-carotene (50.67 IU/1010 g) was found in 60 × 60 cm.

Gayathri and Krishnaveni (2015) a study was carried out to find the effect of organic manures and inorganic fertilizers on ascorbic acid in okra (*Abelmoschus esculentus* L.) cv. Arka Anamika. Farm yard manure @ 20 t/ha and 50 per cent of RDF + 50 per cent of RDN through FYM treatments recorded maximum ascorbic acid (19.67 mg/100 g).

Jabeen *et al.* (2018) revealed that spinach beet the quality parameters like dry matter content (15.92, 16.47 and 29.26 %), ascorbic acid content (202.52, 166.10 and 155.12 mg 100/ g), were highest with the treatment T₆ (vermicompost @ 3 tonnes /ha + biofertilizers @ 5 kg/ ha).

Nchang *et al.* (2018) a field experiment was carried out to evaluate the integrated effect of chemical fertilizers, organic manures and biofertilizers on yield and quality of chilli under the foothill condition of Nagaland. Results revealed that integrated application of chemical fertilizers, organic manures and biofertilizers significantly increased the yield and quality, characters of chilli over control. The highest vitamin C (247.16

mg/100g) were recorded with the application of 50 % NPK + 50 % FYM + Biofertilizers.

Yadav *et al.* (2019) revealed that in spinach the application of 75 % RDF (112.5:60:75 kg NPK/ ha) + 10 t vermicompost /ha + 5 kg PSB /ha + 5 kg azotobacter / ha was recorded significantly maximum vitamin 'C' (49.6, 51.0 and 50.30 mg /100 g) at first year, second year and pooled, respectively as compared to control.

2.4 Soil analysis (after harvesting)

Melero *et al.* (2006) said that availability of major plant nutrients like N, P₂O₅ and K₂O were also affected by application of different nutrients. In all cases the nutrient availability increased and the highest availability of N₂, P₂O₅ and K₂O was found in T₃ [50 % RD of NPK + vermicompost @ 2 t/ ha (mixed with microbial consortium)].

Ewulo *et al.* (2008) studied the effect of poultry manure additions on nutrient availability, soil physical and chemical properties and yield of tomato, five levels of the manure, namely 0, 10, 25, 40 and 50 t/ ha were applied at Akure, Southwest Nigeria. The soil at the two experimental sites were slightly acidic, low in organic matter, N, P₂O₅, and Ca. Poultry manure increased soil organic matter, N and P₂O₅.

Katiyar *et al.* (2014) a field experiment was conducted during 2008 and 2009 at Banthra research station of CSIR-National Botanical Research Institute, to determine suitable plant spacing to obtain chemical properties of reclaimed sodic soil of northern Indian plains. Result showed that 45 cm row spacing significantly influenced pH, EC, available nitrogen,

available phosphorous and available potassium in degraded lands.

Joshi *et al.* (2016) an experiment was carried out on loamy sand soil to evaluate the effect of organic manures (farmyard manure, vermicompost, poultry manure, neem cake and castor cake) on soil and quality parameters of cowpea during summer season of 2014. Soil chemical parameters *viz.*, EC, available N, P₂O₅ and K₂O were found to be affected significantly due to different treatments. Higher OC content after harvest of the crop was reported under treatment Poultry manure 2 t/ha. Whereas, treatment vermicompost @ 2 t/ha recorded significantly reduction in EC over control, however, different treatments failed to exert their significant influence on soil pH after harvest of the crop. Significantly higher values of available nutrients (N, P₂O₅ and K₂O) in the soil after harvest of the crop was observed under the treatment VC 2 t/ ha, FYM 2.5 t/ ha and PM 2 t/ ha, respectively.

Kumar *et al.* (2017) conducted a field experiment at the Experimental Farm, Department of Horticulture, Assam Agricultural University, Jorhat during March to July 2016 to study the effect of “Integrated nutrient management in okra (*Abelmoschus esculentus* (L.) Monech). Organic manures, inorganic fertilizers were applied in different combinations along with biofertilizers. They revealed that the highest available nitrogen available (211.29 kg/ha), phosphorous (64.05 kg/ha) and available potassium (154.27 kg/ha) is recorded in T₃ [50% RD of NPK + (mixed vermicompost @ 2 t/ ha with microbial consortium)].

Mansa (2017) conducted field experiment on “effect of plant densities and nitrogen levels on growth and yield of Red cabbage.” The available nitrogen (157.47 kg/ha) significantly higher at spacing 60 × 60 cm.

CHAPTER III

MATERIAL AND METHOD

The information regarding material used and methods followed during the course of present investigation entitled “effect of spacing and organic manure on growth and yield performance of Indian spinach” was undertaken at College of Horticulture, Dapoli; Dist. Ratnagiri (MS) during the year 2019-2020. The field experiment was conducted on following objectives:

1. To study the effect of spacing on growth and yield of Indian spinach
2. To study the effect of organic manure on growth and yield of Indian spinach
3. To find out the optimum spacing and organic manure for maximization of yield of Indian spinach

The material used and methodology adopted during the present investigation have been explained in this chapter.

3.1 Experimental site:

The field experiment was conducted at College of Horticulture, Dapoli, Dist. Ratnagiri (MS) during 2019-2020. The plot was selected on the basis of suitability of soil and its topography for Indian spinach.

3.2 Soil:

The soil of the experimental plot was red lateritic and acidic in nature with pH ranging from 5.6 – 6.6 with uniform depth and good drainage. The selection of site has done on the basis of suitability of land for cultivation of Indian spinach.

3.3 Climate and weather conditions

Dapoli is situated on West Coast of Maharashtra at an altitude of 174 meters above MSL. Its position on the world map is 17° 74' North latitude and 73° 18' East longitudes. The average minimum and maximum temperatures recorded during 2019-2020 were 15.6°C and 32.8°C respectively.

The average annual rainfall received during 2019-2020 was 3500 mm, normally distributed from June to October. Mean relative humidity was 73.78 per cent during the period of experiment. The relevant meteorological observations recorded during the period of experimentation have presented in Appendix-II.

3.4 Details of experiment:

3.4.1 Treatment details:

Two factors namely spacing and organic manure. Thus, the combination of three main plot treatments (spacing) and four sub plot treatments (organic manure) resulted in twelve treatment combinations. These treatment combinations were replicated three times in split plot design having thirty six experimental blocks. The other details are furnished below. The recommended management practices of Dr. B.S.K.K.V Dapoli were followed throughout the experimental period.

Treatment details

The treatment details are as follows:

- | | |
|------------------------|---------------------|
| a) Design | : Split Plot Design |
| b) Plot size | : 3.6 m × 2.5 m |
| c) Replication | : 3 |
| d) Treatment details:- | |

First factor (Factor A) - Spacing

Levels 3 - S₁- 50 × 30 cm

S₂- 50 × 45 cm

S₃- 50 × 60 cm

Second factor (Factor B) - Organic manures

Levels 4 - M₁- FYM @ 10 t/ha + 100:50:50 kg/ha NPK

M₂- Vermicompost @ 5 t/ha

M₃- Poultry manure @ 4 t/ha

M₄- Neem cake @ 2 t/ha

There were 12 treatment combinations namely S₁M₁, S₁M₂, S₁M₃, S₁M₄, S₂M₁, S₂M₂, S₂M₃, S₂M₄, S₃M₁, S₃M₂, S₃M₃, S₃M₄.

3.4.2 **Season:**

The field experiment was conducted during the *kharif and summer* season in the year 2019-2020.

3.4.3 **Land preparation:**

The selected experimental field was ploughed on 27th June 2019 with a power tiller and was exposed to the sun for a week. After a week of ploughing the land was harrowed several times followed by laddering to obtain a good tilth. Weeds and stubbles were removed and finally obtained a desirable tilth of soil for sowing *basella* seed. Land was levelled and laid out as per the layout plan.

3.4.4 **Experimental design and layout:**

Two factors experiment was laid out following split plot design (SPD) with three replications. An area of 25.4 m × 18.0 m was divided into three equal blocks. Each block was divided into 12 plots where 12 treatment combinations were allotted at random. There were 36 unit plots and the size of the each unit plot was 3.6 m × 2.5 m. The distance maintained between two

blocks and replication were 0.6 m and 1.0 m respectively. The seedlings were planted with maintaining distance row to row 50 cm and plant to plant 30 cm, 45 cm and 60 cm as per plant spacing treatment. The layout of the experiment has shown in Figure 1.

3.4.5 Organic Manure application:

Manure were applied as per treatments to each plot. Required quantity of FYM @ 10 t/ha along with 100:50:50 kg/ha NPK, 5 t/ha vermicompost, 4 t/ha poultry manure and 2 t/ha neem cake were applied to plot and mixed thoroughly with soil.

3.5.1 Experimental material:

The seeds of Indian spinach and other materials for the present experimental study were obtained from the College of Horticulture, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. After procuring the seeds, the viability and germination percentage was assessed in laboratory for uniform germination of seeds in field before sowing.

3.5.2 Seed sowing:

Seeds have sown at different spacing as per the treatments *i.e.* in S₁ plot (50 × 30 cm), the seeds were sown at 1 cm depth and covered uniformly with thin layer of soil.

3.6 Intercultural operation:

After emergence of seedling, other intercultural operations were followed as per recommendation as when necessary for better growth and development of the plant, which were as follows:



Plate: 1 **General view of experimental plot**





S₁: i.e. 50 × 30 cm



S₂: i.e. 50 × 45 cm



S₃ i.e. 50 × 60 cm

Plate 2. Field view of plots under different spacing

3.6.1 Gap filling:

Gap filling has done 30 days after sowing. Dead, injured and weak seedlings were replaced by healthy seedlings.

3.6.2 **Weeding:**

The manual weeding was accomplished as and when necessary to keep the crop free from weeds and easy aeration of soil which ultimately ensured better growth and development.

3.6.3 **Irrigation:**

Initially, during *Kharif* season Indian spinach was grown as rainfed. During *summer* season, irrigation was given with the help of micro sprinklers throughout the growing period at interval of 2-3 days.

3.7 **Harvesting:**

It has done by cutting the tender shoot and leaves of plants with the help of sharp knife and making them into bundles weighing of around 300-450 g each.

3.8 **Collection of data:**

Five plants from each plot were randomly selected and tagged as observational plants for recording observations. The plants in the outer rows and the extreme end of the middle rows were excluded from the random selection to avoid the border effect. The following observations were recorded for data collection.

3.8.1 **Growth characters:**

Five plants were selected randomly from each plot for recording observations. Average value was noted for respective

observation. Growth observations namely plant height, number of leaves, number of branches, inter-nodal length, stem diameter and total leaf area were recorded at monthly interval from 45 DAS to 225 DAS, while growth observations were recorded at 45, 75, 105, 135, 165, 195 and 225 DAS.

3.8.1.1 **Plant height** (cm)

The height of the plant from the base *i.e.* ground level to the top most growing point was measured with the help of a scale and expressed in centimeters.

3.8.1.2 **Stem diameter** (mm)

Stem/stalk diameter at the collar was measured by Vernier Calliper.

3.8.1.3 **Number of leaves**

Matured, marketable leaves were counted for five randomly selected plants in a plot and their mean has taken as number of leaves per plant

3.8.1.4 **Inter-nodal length** (cm)

The inter-nodal length was calculated by dividing the height of the plant by number of nodes present per plant and expressed in centimeter.

3.8.1.5 **Number of branches**

The number of branches per plant was counted and average of five plants was worked.

3.8.1.6 **Leaf area** (cm²)

The leaf area of first five leaves from base of five tagged plants of each plot were obtained at 30 days after sowing by leaf area meter (LI-COR) and was expressed in cm².

3.8.2 Yield attributing characters:

3.8.2.1 Herbage yield per plant (g)

The yield of green herbage of Indian spinach from selected five plants from each treatment was noted after harvesting and average was worked out.

3.8.2.2 Herbage yield per plot (kg)

Green herbage yield of all plants from the each treatment plot including five selected plants were recorded as yield per plot.

3.8.2.3 Total herbage yield per plant (g)

The total yield of green herbage were removed from selected five plants with the help of analytical balance at the time of harvest and recorded in grams.

3.8.2.4 Total herbage yield per plot (kg)

Entire plants in the plot were harvested, weighed after tying as bundles and expressed in kg per plot.

3.8.2.5 Total herbage yield per hectare (t)

The yield per plot was converted into yield per hectare on an area basis and expressed in tons per hectare.

3.8.3 Physiochemical characters:

3.8.3.1 Absolute growth rate (cm/day)

Absolute growth rate (AGR) of seedling was calculated as per the formula given by Hunt and Parsons, (1974) used in the study is as follows,

$$\text{AGR} = \frac{(H_2 - H_1)}{(t_2 - t_1)}$$

Where, H_2 and H_1 represent height per plant and $t_2 - t_1$ is the time interval respectively.

3.8.3.2 **Relative growth rate** (cm/cm/day)

Relative growth rate (RGR) of seedling was calculated as per the formula given by West *et al.* (1920) used in the study is as follows,

$$\text{RGR} = \frac{(\log_e H_2 - \log_e H_1)}{(D_2 - D_1)}$$

Where, H_2 and H_1 represent height per seedling at D_2 and D_1 days respectively.

3.8.3.3 **Determination of β – carotene (Vitamin A)** (mg/100 g)

The total carotenoid pigments expressed as β -carotene were determined with the method described by (Rangana, 1995). The results were expressed in terms of β -carotene as mg/100g sample.

Five gram of fresh sample were taken and crushed in to 10 to 15 ml acetone. Few crystals of anhydrous sodium sulphate were added in the sample. Then supernatant was decanted into a beaker. The process then was repeated twice and combined supernatant was transferred to a separator funnel. In that 10 to 15 ml petroleum ether was added and mixed thoroughly. Two

layers were collected in 100 ml volumetric flask and then the volume was made up to 100 ml with petroleum ether and optical density was recorded at 452 nm using petroleum ether as blank.

$$\beta - \text{carotene} = \frac{\text{O. D.} \times 13.9 \times 104 \times 100}{\text{Weight of sample} \times 560 \times 1000}$$

3.8.3.4 **Ascorbic acid content** (mg/100 g)

Ascorbic acid content of plants was determined by using the procedure given by Rangana (1995) and was expressed in mg/100g.

It was done by 2, 6- dichlorophenol indophenol (DCPIP) titration method. Five ml of the ascorbic acid working standard (500µg/ 5 ml) and 10 ml of 4 percent oxalic acid were pipette out into a 100 ml conical flask. The contents in the flask were titrated against the dye solution (V_1) until the appearance of a pale pink colour that persisted for a few min. Five ml of the test sample was similarly titrated against the dye solution (V_2). Ascorbic acid content was expressed in mg/ 100 g.

$$\text{Ascorbic acid} = \frac{\text{Burette reading} \times \text{Dye factor} \times \text{volume made}}{\text{Volume of filtrate taken} \times \text{Weight of sample}} \times 100$$

3.8.3.5 **Dry matter** (%)

The plant were put into brown paper envelopes, labelled and dried at 60° C for 72 hours using an electric oven. The dry weight of each sample was then recorded using an electric beam balance. Dry matter of plants calculated as per the given formula

$$\text{Dry matter \%} = \frac{(\text{Initial weight} - \text{Final weight})}{(\text{Initial weight})} \times 100$$

3.8.3.6 **Shelf life** (hours)

Five bundles per treatment were selected randomly and their weight was taken each three hours till 12 percent losses in weight and average were calculated.

3.8.4 Collection and preparation of soil samples

The representative surface soil sample (0-22 cm) were collected from per treatment per replication before sowing and at harvest stage. Treatment wise composite soil sample were prepared by principle of quartering .the sample were air dried in shade, pounded in wooden mortar with pestle and sieved through 2 mm sieve. After processing the samples were stored in properly labelled corrugated boxes and used for determination of various physio-chemical properties in the laboratory by using standard analytical methods.

Table: 1 **Initial chemical properties of soil**

Sr. No.	Particulars	Units	Initial value
1.	pH		5.5
2.	EC	dSm ⁻¹	0.12
3.	N	Kg/ha	314.25
4.	P ₂ O ₅	Kg/ha	9.30
5.	K ₂ O	Kg/ha	304.5

Table: 2 **Nutrient composition of organic manures**

Organic manures	pH	EC (dSm ⁻¹)	N (%)	P ₂ O ₅ (%)	K ₂ O (%)
Farm yard manure	8.3	0.17	0.87	0.92	0.72
Vermicompost	8.17	0.18	1.56	0.82	0.90
Poultry manure	7.8	0.16	3.01	2.6	1.82
Neem cake	7.21	0.14	5.1	1.0	1.6

3.8.4.1 Soil chemical properties

3.8.4.1.1 pH

The pH of soil and organic manure was determined using pH meter having glass and calomel electrode using 1:2.5 soil: water suspension ratio (Jackson, 1973).

3.8.4.1.2 **Electrical Conductivity** (dSm⁻¹)

Electrical Conductivity of soil was determined with the help of Systronic conductive meter- 306 using 1:2:5 soil: water suspension ratio (Jackson, 1973).

3.8.4.1.3 **Available nitrogen** (kg/ha)

Available nitrogen was determined by alkaline permanganate (0.32 % KMnO₄) method (Subbiah and Asija 1956).

3.8.4.1.4 **Available phosphorus** (kg/ha)

Available phosphorus (Bray's) was determined by extracting the acid soil P in dilute acid fluoride (Bray and Kurtz, 1965) phosphorus in the extract was determined calorimetrically at 660 nm as described by Black (1965).

3.8.4.1.5 **Available potassium** (kg/ha)

It was estimated on Systronics Flame Photometer-128 using neutral-normal-ammonium acetate (NH₄OAc, pH 7.0) as per procedure given by Jackson (1973).

3.5 **Statistical analysis:**

The statistical analysis of the data was done by using the standard methods as described by Panse and Sukhatme (1995).

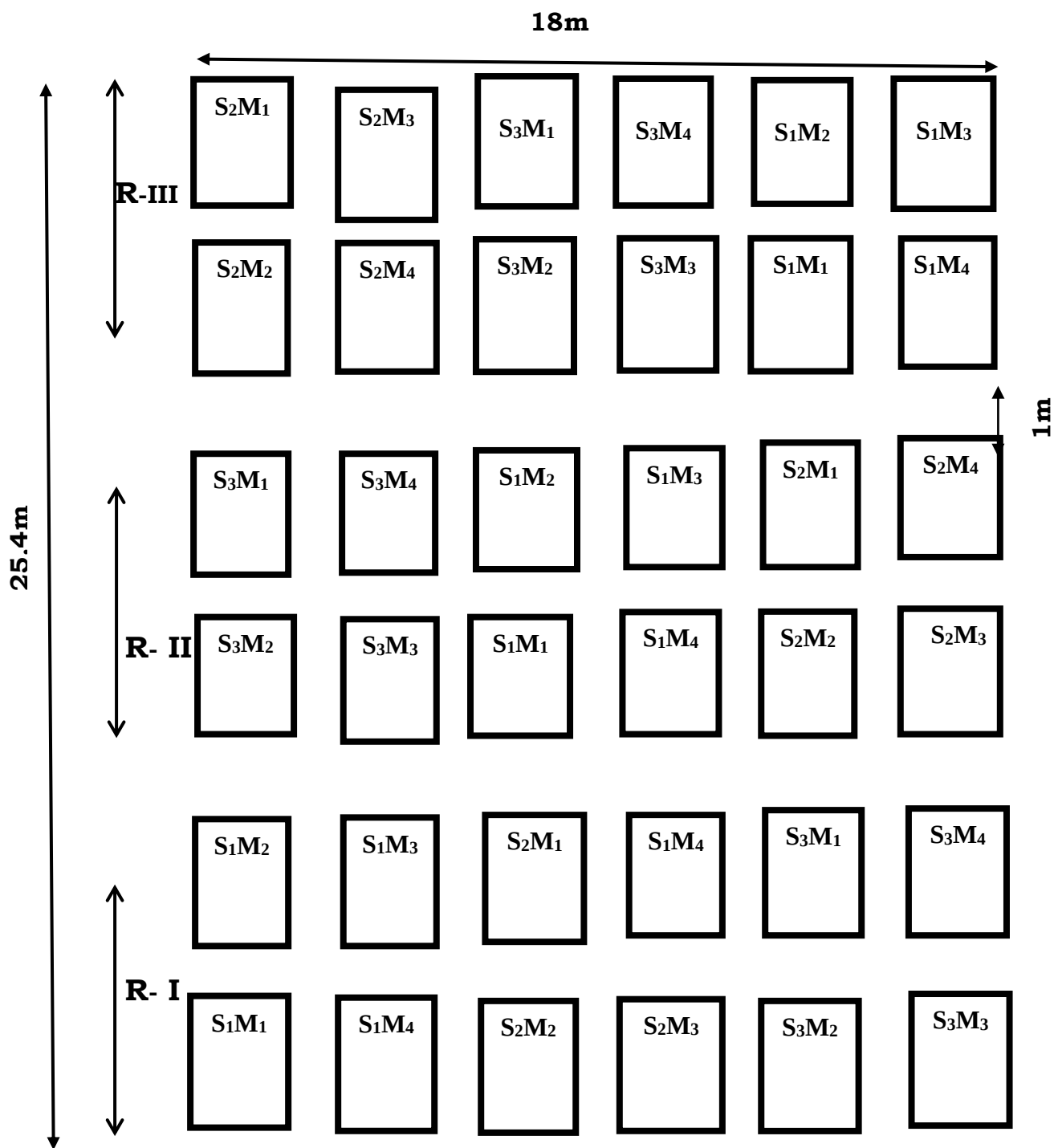


Fig.1 Experimental plot layout

Design	= Split Plot Design
Replications	= 3
No of plots	= 36
Plot size	= 3.6 m × 2.5 m i.e 9.0 m ²
Total area	= 457.2 m ²
Path size	= 0.6 m (between plots)
Species	= <i>Basella rubra</i> L.

CHAPTER IV

RESULT AND DISCUSSION

The present investigation entitled “**effect of spacing and organic manure on growth and yield performances of Indian spinach**” was conducted during *kharif* and *summer* season of 2019-20. The data was statistically analyzed and results are presented under following headings and sub headings.

4.1 **Growth parameters:**

The growth parameters *viz.*, plant height, stem diameter, number of leaves, inter-nodal length, number of branches and leaf area which decide vigor of the plant. Variation in growth parameters due to spacing, organic manure and their interaction was observed. The details are as below.

4.1.1 **Plant height (cm):**

Plant height is one of the important growth parameters and is a dominant part of plant architecture. It is strongly associated with life span, maturity as well as yield. It decides overall structure of the plant and shows extent of growth vigor in the plant.

The effect of spacing, organic manure and their interactions on plant height was studied at 45, 75, 105, 135, 165, 195 and 225 DAS. Further, it was observed that the spacing, organic manure and their interaction had significant effect on the plant height at all growth stages of Indian spinach were presented in Table 3a and 3b and illustrated in Fig. 2.

4.1.1.1 **Effect of spacing (S):**

At 45 DAS, significantly highest plant height (22.14 cm) was recorded with treatment S₁ (50 × 30 cm) and it was found significantly superior over rest of all the spacing treatments.

However, the minimum plant height (17.69 cm) was recorded with treatment S₃ (50 × 60 cm).

The trend of effect of spacing on plant height (cm) at 45 DAS in descending order was as follows,

$$\underline{S_1} > S_2 > S_3$$

At 75 DAS, significantly highest plant height (30.63 cm) was observed with treatment S₃ (50 × 60 cm). However, the lowest plant height (24.67 cm) was recorded with treatment S₁ (50 × 30 cm).

The trend of effect of spacing on plant height (cm) at 75 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 105 DAS, the highest plant height (32.57 cm) was recorded with treatment S₃ and it was found significantly superior over rest of the spacing. Whereas, the lowest plant height (26.78 cm) was recorded with treatment S₁.

The trend of effect of spacing on plant height (cm) at 105 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 135 DAS, the highest plant height (35.07 cm) was observed with spacing 50 × 60 cm and it was found significantly superior over rest of all the spacing levels. However, the lowest plant height (31.53 cm) was recorded with spacing 50 × 30 cm.

The trend of effect of spacing on plant height (cm) at 135 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

Similarly, at 165 DAS, the highest plant height (40.68 cm) was found with treatment S₃ and it was found significantly superior over rest of all treatments. However, the lowest plant height (33.84 cm) was found with treatment S₁.

The trend of effect of spacing on plant height (cm) at 165 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 195 DAS, the highest plant height (49.53 cm) was recorded with treatment S₃ and it was found significantly superior over rest of all the treatments. However, the lowest plant height (42.26 cm) was observed with treatment S₁.

The trend of effect of spacing on plant height (cm) at 195 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 225 DAS, significantly highest plant height (51.05 cm) was recorded with treatment S₃. However, the lowest plant height (47.59 cm) was recorded with treatment S₁ followed by S₂ (48.18 cm).

The trend of effect of spacing on plant height (cm) at 225 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

The highest plant height was recorded with wider spacing S₃ (50 × 60 cm) whereas, the lowest plant height was observed in closer spacing (50 × 30 cm). The highest plant height with wider spacing might be due to low plant population per unit area which resulted in optimum space available for proper plant growth as well as availability of nutrients, light, soil moisture and aeration available for plant growth. The similar result was also reported by Rashid *et al.* (1981) in kangkong, Ahbasdokht *et*

al. (2003) in amaranth, Bairagi (2014) in fenugreek and Islam *et al.* (2014) in Indian spinach.

4.1.1.2 **Effect of organic manure (M):**

The data regarding effect of organic manure on plant height of Indian spinach are presented in Table 3a and 3b and illustrated in Fig 2. The plant height of Indian spinach varied significantly among the different organic manure treatments at 45, 75, 105, 135, 165, 195 and 225 DAS.

At 45 DAS, the highest plant height (21.46 cm) was recorded with treatment M₁ (FYM @ 10 t/ha + 100:50:50 kg/ha NPK). Whereas, the lowest plant height (18.55 cm) was recorded with treatment M₄.

The trend of effect of organic manure on plant height (cm) at 45 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

At 75 DAS, the highest plant height (28.73 cm) was recorded with treatment M₁ followed by M₃ (28.52 cm). However, the lowest plant height (27.18 cm) was recorded with treatment M₄.

The trend of effect of organic manure on plant height (cm) at 75 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

Similarly at 105 DAS, the highest plant height (31.86 cm) was recorded with treatment M₁ followed by M₃ (31.73 cm). However, the lowest plant height (27.91 cm) was recorded with treatment M₄.

The trend of effect of organic manure on plant height (cm) at 105 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

At 135 DAS, the highest plant height (36.16 cm) was found with treatment M₁ and it was found significantly superior over other treatment. The lowest plant height (29.69 cm) was recorded with treatment M₄.

The trend of effect of organic manure on plant height (cm) at 135 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 165 DAS, the highest plant height (41.55 cm) was recorded with application of FYM @ 10 t/ha + 100:50:50 kg NPK/ha *i.e.* (M₁) and it was found significantly superior over rest of the treatments. However, the lowest plant height (32.74 cm) was recorded with application of neem cake @ 2 t/ha *i.e.* (M₄).

The trend of effect of organic manure on plant height (cm) at 165 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 195 DAS, the highest plant height (49.33 cm) was recorded with treatment M₁ and it was found significantly superior over rest of all treatments. The lowest plant height (41.57 cm) was recorded with treatment M₄.

The trend of effect of organic manure on plant height (cm) at 195 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 225 DAS, the highest plant height (50.64 cm) was observed with treatment M₁ followed by M₃ (49.99 cm). However, the lowest plant height (47.00 cm) was recorded with treatment M₄.

The trend of effect of organic manure on plant height (cm) at 225 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

The highest plant height was recorded in M_1 might be due to higher availability of nitrogen, phosphorus and potassium to the plants initially through inorganic fertilizers and through FYM fulfilling the needs of plant throughout the cropping season. Similar results were also obtained by Sannigrahi and Borach (2001) in okra, Premsekhar and Rajashree (2009), Kushare *et al.* (2010) and Sanni (2016) in amaranth and Ullah *et al.* (2017) in lettuce.

4.1.1.3 **Interaction effect** ($S \times M$):

The interaction effect between spacing and organic manure on plant height of Indian spinach was varied significantly at all growth stages *i.e.* (45, 75, 105, 135, 165, 195 and 225 DAS) which was presented in Table 3a and 3b and depicted in fig. 2.

At 45 DAS, significantly highest plant height (23.25 cm) was recorded with treatment combinations S_1M_1 which was at par with S_1M_3 (23.16 cm) while, the lowest plant height (16.34 cm) was found with treatment combinations S_3M_4 which was at par with S_3M_2 (16.54 cm).

The trend of various treatment combinations on plant height at 45 DAS in descending order was as follow,

$$\underline{S_1M_1} > \underline{S_1M_3} > S_2M_1 > S_1M_2 > S_1M_4 > S_2M_3 > S_3M_1 > S_2M_2 > S_2M_4 > \\ S_3M_3 > \underline{S_3M_2} > \underline{S_3M_4}$$

At 75 DAS, significantly highest plant height (31.77 cm) was recorded with treatment combination S_3M_1 followed by S_3M_3 (31.66 cm) while, the treatment combination S_1M_4 recorded the

lowest plant height (24.33 cm) followed by S₁M₂ (24.44 cm) and S₁M₃ (24.84 cm).

The trend of various treatment combinations on plant height at 75 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_3M_4 > S_2M_1 > S_3M_2 > S_2M_3 > S_2M_2 > S_2M_4 > S_1M_1 > S_1M_3 > S_1M_2 > S_1M_4$$

At 105 DAS, significantly highest plant height (34.14 cm) was recorded with treatment combination S₃M₁ followed by S₃M₃ (34.11 cm). The lowest plant height (24.39 cm) was recorded in with treatment combination S₁M₄.

The trend of various treatment combinations on plant height at 105 DAS in descending order was as follow

$$\underline{S_3M_1} > S_3M_3 > S_2M_1 > S_2M_3 > S_3M_2 > S_3M_4 > S_1M_1 > S_1M_3 > S_2M_2 > S_2M_4 > S_1M_2 > S_1M_4$$

At 135 DAS, the significantly highest plant height (37.98 cm) was recorded with treatment combination S₃M₁ which was at par with S₃M₃ (37.93 cm) and lowest plant height (28.45 cm) was observed with treatment combination S₁M₄.

The trend of various treatment combinations on plant height at 135 DAS in descending order was as follow

$$\underline{S_3M_1} > \underline{S_3M_3} > S_2M_1 > S_2M_3 > S_1M_1 > S_1M_3 > S_3M_2 > S_2M_2 > S_1M_2 > S_3M_4 > S_2M_4 > S_1M_4$$

At 165 DAS, the significantly highest plant height (44.50 cm) was recorded with treatment combination S₃M₁ which was at par with S₃M₃ (44.36 cm). However, lowest plant height (31.01 cm) was recorded with treatment combination S₁M₄.

The trend of various treatment combinations on plant height at 165 DAS in descending order was as follow,

$$\underline{S_3M_1} > \underline{S_3M_3} > S_2M_1 > S_2M_3 > S_3M_2 > S_1M_1 > S_2M_2 > S_3M_4 > S_1M_3 > S_1M_2 > S_2M_4 > S_1M_4$$

At 195 DAS, the significantly highest plant height (51.67 cm) was recorded with treatment combination S_3M_1 which was at par with S_3M_3 (51.55 cm) whereas, the lowest plant height (38.70 cm) was recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on plant height at 195 DAS in descending order was as follow,

$$\underline{S_3M_1} > \underline{S_3M_3} > S_2M_1 > S_2M_3 > S_3M_2 > S_1M_1 > S_1M_3 > S_3M_4 > S_2M_2 > S_1M_2 > S_2M_4 > S_1M_4$$

Similarly, the significantly highest plant height (53.35 cm) was recorded with the treatment combinations S_3M_1 . However, lowest plant height (46.26 cm) was recorded with treatment combination S_1M_4 which was at par with S_2M_4 (46.32 cm) at 225 DAS.

The trend of various treatment combinations on plant height at 225 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_3M_2 > S_2M_1 > S_2M_3 > S_1M_3 > S_3M_4 > S_1M_1 > S_2M_2 > S_1M_2 > \underline{S_2M_4} > \underline{S_1M_4}$$

Table: 3a **Effect of spacing and organic manure on plant height (cm) of Indian spinach (45, 75, 105 and 135 DAS)**

Plant height (cm)																
Treat ment	45 DAS				75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	23.25	21.77	19.34	21.46	25.07	29.34	31.77	28.73	29.30	32.14	34.14	31.86	33.77	36.74	37.98	36.16
M₂	21.43	18.96	16.54	18.98	24.44	28.66	29.33	27.47	24.45	28.94	31.37	28.25	30.48	31.42	32.51	31.47
M₃	23.16	19.36	18.55	20.36	24.84	29.05	31.66	28.52	28.97	32.10	34.11	31.73	33.41	35.93	37.93	35.75
M₄	20.73	18.59	16.34	18.55	24.33	27.46	29.75	27.18	24.39	28.65	30.68	27.91	28.45	28.75	31.88	29.69
Mean	22.14	19.67	17.69		24.67	28.63	30.63		26.78	30.46	32.57		31.53	33.21	35.07	
	S	M	S × M		S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.04	0.06	0.17		0.006	0.007	0.022		0.001	0.0014	0.004		0.02	0.03	0.08	
CD @ 5%	0.12	0.16	0.48		0.016	0.022	0.065		0.003	0.0040	0.012		0.06	0.08	0.23	

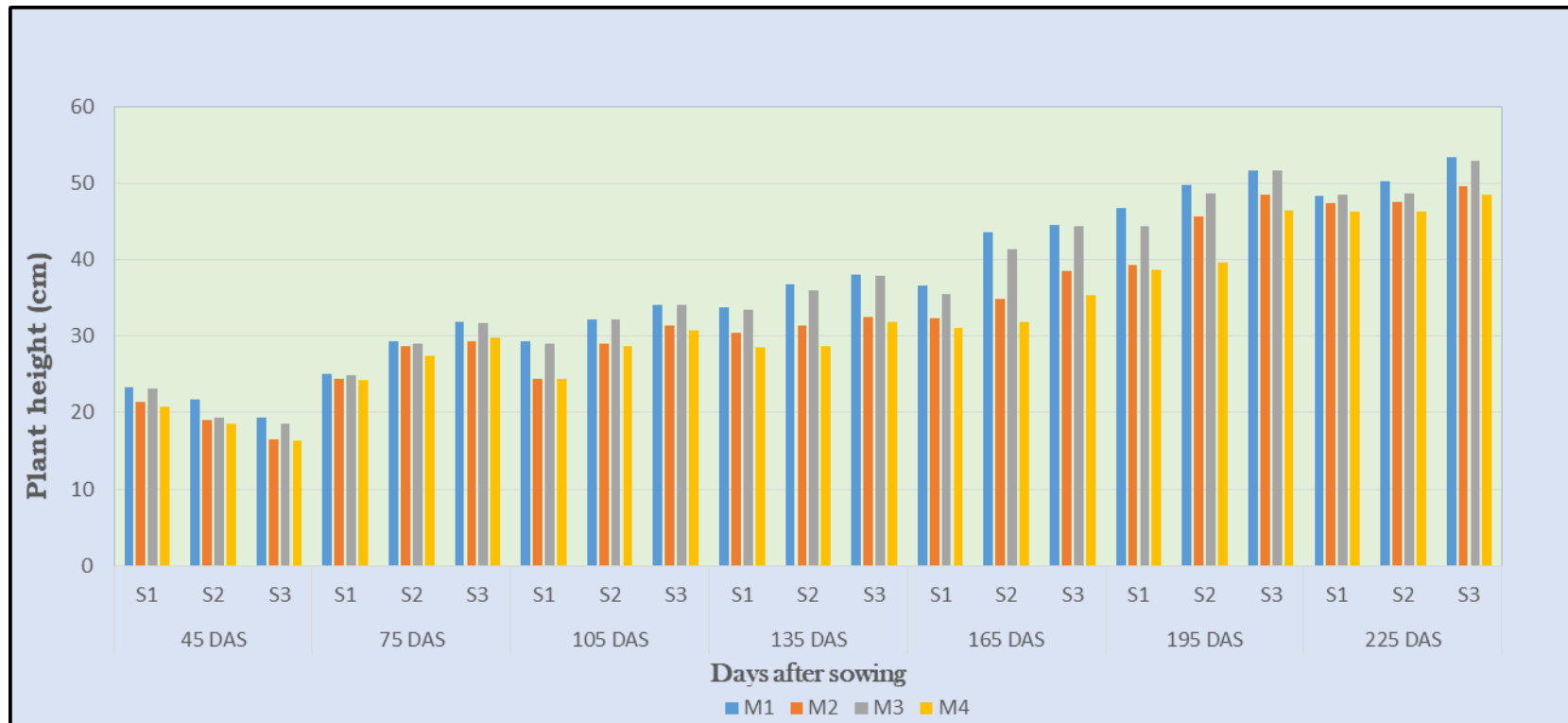
Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm S ₃ :- 50 × 60 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
	M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

Table: 3b **Effect of spacing and organic manure on plant height (cm) of Indian spinach**
(165, 195 and 225 DAS)

Plant height (cm)												
Treatment	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	36.63	43.52	44.50	41.55	46.65	49.66	51.67	49.33	48.31	50.27	53.35	50.64
M₂	32.28	34.87	38.51	35.22	39.28	45.56	48.52	44.45	47.34	47.51	49.52	48.12
M₃	35.43	41.40	44.36	40.40	44.42	48.55	51.55	48.17	48.45	48.63	52.90	49.99
M₄	31.01	31.86	35.35	32.74	38.70	39.64	46.38	41.57	46.26	46.32	48.43	47.00
Mean	33.84	37.91	40.68		42.26	45.85	49.53		47.59	48.18	51.05	
	S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.014	0.02	0.05		0.03	0.04	0.11		0.015	0.02	0.06	
CD @ 5%	0.040	0.05	0.16		0.08	0.11	0.33		0.043	0.06	0.17	

Treatment Details:			
Spacing		Organic manure	
S ₁ :- 50 × 30 cm ,	S ₂ :- 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
S ₃ :- 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

Fig. 2 **Effect of spacing and organic manure on plant height (cm) of Indian spinach** (45, 75, 105, 135,165, 195 and 225 DAS)



Treatment Details:			
Spacing		Organic manure	
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm S ₃ :- 50 × 60 cm		M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
		M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha



Plate No. 3a **Interaction effect of spacing and organic manure on Indian spinach**



Plate No. 3b **Interaction effect of spacing and organic manure on Indian spinach**



Plate No. 3c **Interaction effect of spacing and organic manure on Indian spinach**

The highest plant height was found with treatment combinations S₃M₁ (50 × 60 cm along with FYM @ 10 t/ha + 100: 50: 50 kg/ha NPK) might be due to favorable combination effect of higher spacing along with inorganic fertilizer and FYM. Similar results was obtained by Mekonnen *et al.* (2017) in onion.

4.1.2 **Stem diameter** (mm):

Stem diameter is also an important character which also decide plant vigor. The plant with highest stem girth are supposed to be more vigorous and sturdy.

The data regarding the stem diameter of Indian spinach at 45, 75, 105, 135, 165, 195 and 225 DAS as affected by spacing, organic manure and their interaction is furnished in Table 4a and 4b.

4.1.2.1 **Effect of spacing** (S):

The data regarding effect of spacing on stem diameter are given in Table 4a and 4b. It was observed from the data that stem diameter affected significantly at 45, 75, 105, 135, 165, 195 and 225 days after sowing.

At 45 DAS, significantly highest stem diameter (9.38 mm) was recorded with spacing S₃ (50 × 60 cm) followed by S₂ (9.04 cm). However, the lowest stem diameter (8.42 mm) was recorded with spacing S₁ (50 × 30 cm).

The trend of effect of spacing on stem diameter (mm) at 45 DAS in descending order is as follows,

$$\underline{S_3} > S_2 > S_1$$

At 75 DAS, the highest stem diameter (10.46 mm) was observed with treatment S₃ followed by treatment S₂ (10.23 mm).

The lowest stem diameter (9.62 mm) was recorded with treatment S₁.

The trend of effect of spacing on stem diameter (mm) at 75 DAS in descending order was as follows,

$$S_3 > S_2 > S_1$$

At 105 DAS, the highest stem diameter (11.33 mm) was recorded in wider spacing *i.e.* (S₃) was found significantly superior over rest of all treatments. Whereas, the lowest stem diameter (10.47 mm) was recorded in closer spacing *i.e.* S₁.

The trend of effect of spacing on stem diameter (mm) at 105 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 135 DAS, the highest stem diameter (12.54 mm) was observed with spacing 50 × 60 cm followed by 50 × 45 cm (12.11 mm). However, the lowest stem diameter (11.47 mm) was recorded with spacing 50 × 30 cm.

The trend of effect of spacing on stem diameter (mm) at 135 DAS in descending order was as follows,

$$S_3 > S_2 > S_1$$

At 165 DAS, significantly highest stem diameter (13.48 mm) was found with treatment S₃ (50 × 60 cm) followed by treatment S₂ (13.16 mm). However, the lowest stem diameter (12.33 mm) was found with treatment S₁ (50 × 30 cm).

The trend of effect of spacing on stem diameter (mm) at 165 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 195 DAS, significantly highest stem diameter (14.69 mm) was recorded with treatment S₃ followed by S₂ (14.12 mm). However, the lowest stem diameter (13.05 mm) was recorded with treatment S₁.

The trend of effect of spacing on stem diameter (mm) at 195 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 225 DAS, significantly highest stem diameter (16.78 mm) was recorded with treatment S₃ (50 × 60 cm) spacing and it was found significantly superior over rest of the spacing levels. However, the lowest stem diameter (14.02 mm) was recorded with treatment S₁ (50 × 30 cm) (Table 4b).

The trend of effect of spacing on stem diameter (mm) at 225 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

The maximum stem diameter with respect to spacing was recorded in wider spacing 50 × 60 cm might be due to low plant population with results in optimum space available for plant growth as well as availability of nutrients, light, soil moisture and aeration. Similar results with respect to spacing obtained by Malligawad and Patil (2001) and Khale (2018) in amaranth. These findings are in close conformity with Majumder (2007) in amaranth, Joseph *et al.* (2009), Chavan (2016) and Pawar (2017) and Toungos *et al.* (2018) in amaranth and Madisa *et al.* (2015) in okra.

4.1.2.2 **Effect of organic manure (M):**

The data regarding effect of organic manure on stem diameter of Indian spinach are presented in (Table 4a to 4b). The

stem diameter of Indian spinach was varied significantly among the different organic manure treatments at 45, 75, 105, 135, 165, 195 and 225 days after sowing.

At 45 DAS, significantly the highest stem diameter (9.59 mm) was recorded with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK followed by M₃ (9.03 mm). However, the lowest stem diameter (8.46 mm) was recorded with application of neem cake @ 2 t/ha.

The trend of effect of organic manure on stem diameter (mm) at 45 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 75 DAS, the highest stem diameter (11.22 mm) was recorded with treatment M₁ and it was found significantly superior over rest of all treatments. However, the lowest stem diameter (9.22 mm) was recorded with treatment M₄.

The trend of effect of organic manure on stem diameter (mm) at 75 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

Similarly at 105 DAS, the highest stem diameter (12.58 mm) was recorded with treatment M₁ and it was found significantly superior over rest of the treatments. However, the lowest stem diameter (9.64 mm) was recorded with treatment M₄.

The trend of effect of organic manure on stem diameter (mm) at 105 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 135 DAS, the highest stem diameter (13.59 mm) was found with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK

and it was found significantly superior over rest of the treatments. While, the lowest stem diameter (10.59 mm) was recorded with application of neem cake @ 2 t/ha.

The trend of organic manure on stem diameter (mm) at 135 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 165, significantly highest stem diameter (14.65 mm) was recorded with application of FYM @ 10 t/ha + NPK @ 100:50:50 kg/ha. The lowest stem diameter (11.62 mm) was recorded with application of neem cake @ 2 t/ha.

The trend of effect of organic manure on stem diameter (mm) at 165 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 195 DAS, significantly highest stem diameter (15.49 mm) was recorded with treatment M₁. However, the lowest stem diameter (12.67 mm) was recorded with treatment M₄.

The trend of effect of organic manure on stem diameter (mm) at 195 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 225 DAS, significantly highest stem diameter (17.63 mm) was observed with treatment M₁. However, the lowest stem diameter (13.66 mm) was observed with treatment M₄.

The trend of effect of spacing on stem diameter (mm) at 225 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

The highest stem diameter reported with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK might be due to

optimum availability of essential nutrients (both major and minor). Further, the beneficial role of FYM in improving physico-chemical as well as biological property of soil which resulted in favorable condition for absorption of essential nutrients by plants. Similar results with respect to organic manure obtained by Kushare *et al.* (2010) and Sanni (2016) in amaranth and Mirdudkar *et al.* (2018) and Ola *et al.* in (2018) in okra. This might be attributed to multifarious role of FYM and NPK in supply of nutrients as well as improvement in physical, chemical and biological environment of soil. Finally, it was reflected in better growth of plant with FYM.

4.1.2.3 **Interaction effect** ($S \times M$):

The interaction effect between spacing and organic manure on stem diameter of Indian spinach varied significantly at all growth stages (Table 4a and 4b).

At 45 DAS, significantly highest stem diameter (10.52 mm) was recorded with treatment combination S_3M_1 while, the lowest stem diameter (8.26 mm) recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on stem diameter at 45 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_2M_1 > S_3M_3 > S_2M_3 > S_2M_2 > S_3M_2 > S_3M_4 > S_1M_1 > S_2M_4 > \\ S_1M_3 > S_1M_2 > S_1M_4$$

Similarly, at 75 DAS, significantly the highest stem diameter (11.74 mm) was recorded with treatment combination S_3M_1 followed by S_2M_1 (11.42 mm). While treatment combination S_1M_4 recorded the lowest stem diameter (8.87 mm).

The trend of various treatment combinations on stem diameter at 75 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_2M_1 > S_2M_3 > S_1M_1 > S_3M_3 > S_3M_2 > S_1M_3 > S_2M_2 > S_3M_4 > S_1M_2 > S_2M_4 > S_1M_4.$$

At 105 DAS, significantly highest stem diameter (12.98 mm) was recorded with treatment combination S_3M_1 followed by S_2M_1 (12.90 mm) whereas, the lowest stem diameter (9.24 mm) was recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on stem diameter at 105 DAS in descending order was as follow

$$\underline{S_3M_1} > S_2M_1 > S_3M_3 > S_1M_1 > S_2M_3 > S_3M_2 > S_1M_3 > S_2M_2 > S_1M_2 > S_3M_4 > S_2M_4 > S_1M_4$$

At 135 DAS, significantly highest stem diameter (14.44 mm) was recorded with treatment combination S_3M_1 . However, the lowest stem diameter (10.11 mm) was recorded with treatment combination S_1M_4 followed by S_2M_4 (10.46 mm).

The trend of various treatment combinations on stem diameter at 135 DAS in descending order was as follow;

$$\underline{S_3M_1} > S_2M_1 > S_3M_3 > S_1M_1 = S_2M_3 > S_3M_2 > S_1M_3 > S_2M_2 > S_1M_2 > S_3M_4 > S_2M_4 > S_1M_4$$

At 165 DAS, significantly the highest stem diameter (15.57 mm) was recorded with treatment combination S_3M_1 . However, lowest stem diameter (10.69 mm) was recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on stem diameter at 165 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_2M_1 > S_1M_1 > S_3M_3 > S_2M_3 > S_1M_3 > S_2M_2 > S_3M_2 > S_3M_4 > \\ S_2M_4 > S_1M_2 > S_1M_4$$

At 195 DAS, significantly the highest stem diameter (16.68 mm) was recorded with treatment combination S_3M_1 . Whereas, the lowest stem diameter (11.93 mm) was recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on stem diameter at 195 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_2M_1 > S_3M_3 > S_2M_3 > S_1M_1 > S_3M_2 > S_1M_3 > S_2M_2 > S_3M_4 > \\ S_2M_4 > S_1M_2 > S_1M_4$$

At 225 DAS, significantly the highest stem diameter (19.86 mm) was recorded with treatment combination S_3M_1 . However, the lowest stem diameter (12.44 mm) was recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on stem diameter at 225 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_2M_1 > S_3M_3 > S_2M_3 > S_1M_1 > S_3M_2 > S_1M_3 > S_2M_2 > S_3M_4 \\ > S_2M_4 > S_1M_2 > S_1M_4$$

The highest stem diameter was recorded with treatment combinations S_3M_1 might be due to favorable combination effect of spacing and organic manure on stem diameter of Indian spinach.

Table: 4a **Effect of spacing and organic manure on stem diameter (mm) of Indian spinach**
(45, 75, 105 and 135 DAS)

Treatment	Stem diameter (mm)															
	45 DAS				75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	8.58	9.67	10.52	9.59	10.49	11.42	11.74	11.22	11.87	12.90	12.98	12.58	12.67	13.67	14.44	13.59
M₂	8.37	8.93	8.80	8.70	9.17	9.65	10.12	9.65	10.17	10.36	10.78	10.44	11.32	11.66	11.82	11.60
M₃	8.46	9.08	9.56	9.03	9.93	10.61	10.43	10.32	10.58	10.85	11.51	10.98	11.78	12.67	12.71	12.39
M₄	8.26	8.48	8.65	8.46	8.87	9.23	9.55	9.22	9.24	9.60	10.07	9.64	10.11	10.46	11.20	10.59
Mean	8.42	9.04	9.38		9.62	10.23	10.46		10.47	10.93	11.33		11.47	12.11	12.54	
	S	M	S × M		S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.0009	0.001	0.0034		0.0008	0.001	0.0031		0.00014	0.0002	0.001		0.0005	0.0007	0.002	
CD @ 5%	0.0025	0.003	0.0101		0.0023	0.003	0.0090		0.00041	0.0005	0.002		0.0016	0.0021	0.006	

Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm		M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK
S ₃ :- 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha
		M ₃ :- Poultry manure @ 4 t/ha
		M ₄ :- Neem cake @ 2 t/ha

Table: 4a **Effect of spacing and organic manure on stem diameter (mm) of Indian spinach**
(165,195 and 225 DAS)

Stem diameter (mm)												
Treatment	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	13.80	14.58	15.57	14.65	14.17	15.61	16.68	15.49	15.31	17.73	19.86	17.63
M₂	11.86	12.61	12.52	12.33	12.31	13.77	13.79	13.29	13.55	14.60	15.64	14.60
M₃	12.96	13.53	13.61	13.37	13.77	14.33	14.94	14.35	14.77	16.40	16.71	15.96
M₄	10.69	11.93	12.23	11.62	11.93	12.75	13.33	12.67	12.44	13.62	14.92	13.66
Mean	12.33	13.16	13.48		13.05	14.12	14.69		14.02	15.59	16.78	
	S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.0005	0.001	0.13		0.0042	0.006	0.017		0.0028	0.004	0.011	
CD @ 5%	0.0014	0.002	0.38		0.0122	0.016	0.049		0.0081	0.011	0.033	

Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm		M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK M ₃ :- Poultry manure @ 4 t/ha
S ₃ :- 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha M ₄ :- Neem cake @ 2 t/ha

4.1.3 **Number of leaves:**

Number of leaves produced by each plant is an important growth parameter which is one of the leading factors deciding the tonnage of the crop harvested especially in the leafy vegetables.

4.1.3.1 **Effect of spacing (S):**

The data regarding effect of spacing on number of leaves per plant are given in Table 5a and 5b. It was observed from the data that number of leaves affected significantly at 45, 75, 105, 135, 165, 195 and 225 days after sowing.

At 45 DAS, significantly the highest number of leaves (22.40) was recorded with treatment S₂. Whereas the lowest number of leaves (17.85) was recorded with treatment S₁.

The trend of effect of spacing on number of leaves at 45 DAS in descending order is as follows,

$$\underline{S_2} > S_3 > S_1$$

At 75 DAS, significantly highest number of leaves (44.69) was observed with treatment S₂ and it was found significantly superior over rest of the treatments. However, the lowest number of leaves (40.65) was recorded with treatment S₁.

The trend of effect of spacing on number of leaves at 75 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 105 DAS, significantly the highest number of leaves (55.42) was recorded with treatment S₂ and lowest number of leaves (50.73) was recorded with treatment S₁.

The trend of effect of spacing on number of leaves at 105 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

Similarly at 135 DAS, the highest number of leaves (60.40) was observed with treatment S₂ and it was found significantly superior. However, the lowest number of leaves (55.80) was recorded with treatment S₁.

The trend of effect of spacing on number of leaves at 135 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 165 DAS, the highest number of leaves (57.62) was found with treatment S₂ and it was found significantly superior. The lowest number of leaves (50.29) was found with treatment S₁.

The trend of effect of spacing on number of leaves at 165 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 195 DAS, significantly highest number of leaves (56.19) was recorded with treatment S₂. However, the lowest number of leaves (50.50) was recorded with treatment S₁.

The trend of effect of spacing on number of leaves at 195 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 225 DAS, significantly highest number of leaves (52.61) was recorded with treatment S₂ whereas, the lowest number of leaves (48.33) was recorded with treatment S₁.

The trend of effect of spacing on number of leaves at 225 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

The highest number of leaves was recorded in optimum spacing S₂ whereas, the lowest was observed in S₁ i.e. closer

spacing. The highest number of leaves was recorded in optimum spacing might be due to number of leaves remarkably accelerated under optimum spacing and relatively least competition exerted between crop plants which important role in enhancing the vegetative growth resulting higher number of leaves. Similar trends of result were also obtained by Akinfasoye *et al.* (2008) in celosia, Islam *et al.* (2014) in Indian spinach, Lavanya *et al.* (2017) in radish, Kumar *et al.* (2011) and Tandel *et al.* (2017) in okra. The plants grown with optimum spacing 50 × 45 cm received higher amount of light, nutrient, water thus attaining more height along with more number of leaves per plant and the reverse happened to plants grown with closer spacing *i. e.* S₁ (50 × 30 cm).

4.1.3.2 **Effect of organic manure (M):**

The data regarding effect of organic manure on number of leaves of Indian spinach are presented in (Table 5a and 5b) and illustrated in Fig 3. The number of leaves of Indian spinach varied significantly among the different organic manure treatments at 45, 75, 105, 135, 165, 195 and 225 DAS.

At 45 DAS, the highest number of leaves (24.44) was recorded with treatment M₁ and it was found significantly superior. However, the lowest number of leaves (16.62) was recorded with treatment M₄.

The trend of effect of spacing on number of leaves at 45 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 75 DAS, significantly the highest number of leaves (45.19) was recorded with treatment M₁ followed by M₃ (44.15)

and lowest number of leaves (39.83) was recorded with treatment M₄.

The trend of effect of spacing on number of leaves at 75 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

At 105 DAS, the highest number of leaves (56.11) was recorded with treatment M₁ and it was found significantly superior over rest of the organic manure levels. However, the lowest number of leaves (50.04) was recorded with treatment M₄.

The trend of effect of spacing on number of leaves at 105 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 135 DAS, the highest number of leaves (55.38) was found with treatment M₁ and it was found significantly superior over rest of the organic manure treatments. While, the lowest number of leaves (48.10) was recorded with treatment M₄.

The trend of effect of spacing on number of leaves at 135 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 165 DAS, significantly the highest number of leaves (57.62) was recorded with treatment M₁ and it was found significantly superior. The lowest number of leaves (50.29) was recorded with treatment M₄.

The trend of effect of spacing on number of leaves at 165 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

Similarly, at 195 DAS, the highest number of leaves (57.39) was recorded with treatment M₁ and lowest number of leaves (48.79) was recorded with treatment M₄.

The trend of effect of spacing on number of leaves at 195 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

At 225 DAS, significantly highest number of leaves (55.59) was observed with treatment M₁. However, the lowest number of leaves (45.62) was recorded with treatment M₄.

The trend of effect of spacing on number of leaves at 225 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

It was noticed that the number of leaves was recorded highest with M₁ *i. e.* application of FYM @ 10 t/ha + 100:50:50 kg /ha NPK might be due to higher availability of nitrogen, phosphorus and potassium to the plants initially through inorganic fertilizer along with FYM, as well through fulfilling the needs of plant throughout the cropping season. Similar findings was also recorded by Kushare *et al.* (2010) and Sanni (2016) in amaranth and Sharma *et al.* (2013) in radish, Chaudhari *et al.* (2018), Mirdudkar *et al.* (2018) and Ola *et al.* (2018) in okra.

4.1.3.3 **Interaction effect** (S × M):

The interaction effect between spacing and organic manure on number of leaves of Indian spinach was varied significantly at all growth stages (Table 5a and 5b) and fig. 3.

At 45 DAS, significantly the highest number of leaves (26.20) was recorded with treatment combination S₂M₁. While,

the lowest number of leaves (14.77) was found with treatment combination S₁M₄.

The trend of various treatment combinations on number of leaves at 45 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_3M_1 > S_1M_1 > S_2M_3 > S_2M_2 > S_3M_3 > S_3M_2 > S_2M_4 > S_1M_3 > S_3M_4 > S_1M_2 > S_1M_4$$

At 75 DAS, significantly highest number of leaves (47.77) was recorded with treatment combination S₂M₁ while, S₁M₄ recorded the lowest number of leaves (37.80).

The trend of various treatment combinations on number of leaves at 75 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_2M_3 > S_3M_1 > S_3M_3 > S_2M_2 > S_1M_1 > S_3M_2 > S_1M_3 > S_2M_4 > S_3M_4 > S_1M_2 > S_1M_4$$

At 105 DAS, significantly highest number of leaves (58.73) was recorded with treatment combination S₂M₁. The lowest number of leaves (47.90) was recorded with treatment combination S₁M₄.

The trend of various treatment combinations on number of leaves at 105 DAS in descending order was as follow

$$\underline{S_2M_1} > S_2M_3 > S_3M_1 > S_3M_3 > S_2M_2 > S_1M_1 > S_3M_2 = S_2M_4 > S_1M_3 > S_3M_4 > S_1M_2 > S_1M_4$$

At 135 DAS, significantly highest number of leaves (58.47) was recorded with treatment combination S₂M₁. The lowest number of leaves (46.40) was observed with treatment combination S₁M₄.

The trend of various treatment combinations on number of leaves at 135 DAS in descending order was as follow

$$\underline{S_2M_1} > S_3M_1 > S_2M_3 > S_1M_1 > S_2M_2 > S_3M_3 > S_3M_2 > S_1M_3 > S_1M_2 > S_2M_4 > S_3M_4 > S_1M_4$$

At 165 DAS, significantly highest number of leaves (62.67) was recorded with treatment combination S_2M_1 . However, the lowest number of leaves (45.60) was recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on number of leaves at 165 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_3M_1 > S_1M_1 > S_2M_3 > S_2M_2 > S_3M_3 > S_2M_4 > S_3M_2 > S_1M_3 > S_3M_4 > S_1M_2 > S_1M_4$$

At 195 DAS, significantly highest number of leaves (60.67) was recorded with treatment combination S_2M_1 whereas, lowest number of leaves (45.67) was recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on number of leaves at 195 DAS in descending order was as follow,

$$S_2M_1 > S_2M_3 > S_3M_1 > S_3M_3 > S_2M_2 > S_1M_1 > S_3M_2 > S_1M_3 > S_2M_4 > S_1M_2 > S_3M_4 > S_1M_4$$

At 225 DAS, significantly highest number of leaves (58.18) was recorded with treatment combination S_2M_1 . However, the lowest number of leaves (43.07) was recorded with treatment combination S_1M_4 .

Table: 5a **Effect of spacing and organic manure on number of leaves of Indian spinach**
(45, 75, 105 and 135 DAS)

Number of leaves																
Treat ment	45 DAS				75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	22.70	26.20	24.43	24.44	43.13	47.77	44.67	45.19	53.10	58.73	56.50	56.11	53.00	58.47	54.67	55.38
M₂	16.47	20.70	18.50	18.56	39.77	43.63	42.03	41.81	50.10	54.20	52.10	52.13	50.90	55.23	53.53	53.22
M₃	17.47	24.10	23.46	21.68	41.90	46.27	44.27	44.15	51.83	56.63	54.27	54.24	51.53	56.08	53.29	53.63
M₄	14.77	18.60	16.50	16.62	37.80	41.07	40.63	39.83	47.90	52.10	50.13	50.04	46.40	50.20	47.70	48.10
Mean	17.85	22.40	20.72		40.65	44.69	42.90		50.73	55.42	53.25		55.80	60.40	57.27	
	S	M	S × M		S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.E.m.±	0.04	0.06	0.17		0.02	0.03	0.10		0.12	0.12	0.20		0.04	0.06	0.17	
CD @ 5%	0.13	0.17	0.51		0.07	0.09	0.28		0.47	0.35	0.59		0.12	0.16	0.49	

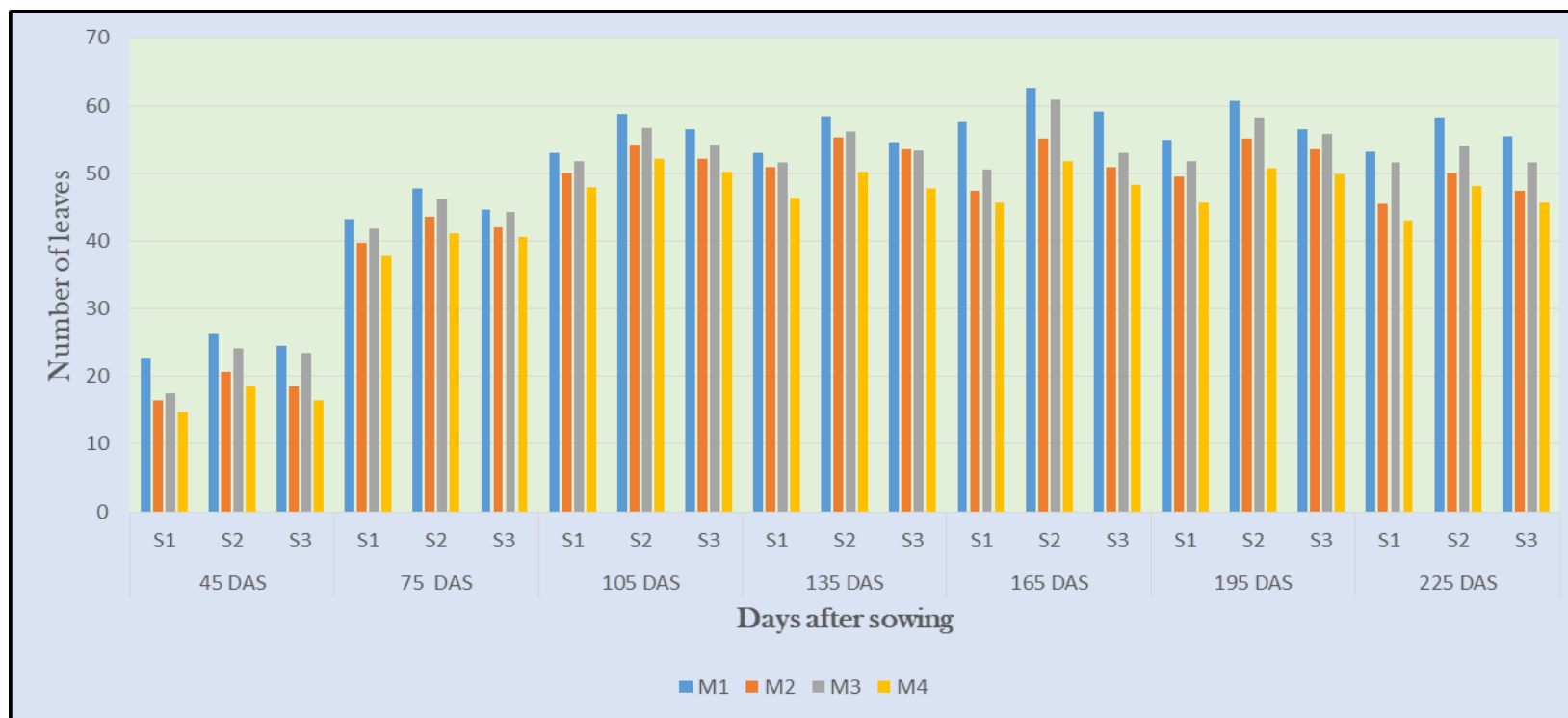
Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm S ₃ :- 50 × 60 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	
	M ₂ :- Vermicompost @ 5 t/ha	M ₃ :- Poultry manure @ 4 t/ha M ₄ :- Neem cake @ 2 t/ha

Table: 5b **Effect of spacing and organic manure on number of leaves of Indian spinach**
(165,195 and 225 DAS)

Number of leaves												
Treatment	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	57.60	62.67	59.13	59.80	54.90	60.67	56.60	57.39	53.20	58.18	55.40	55.59
M₂	47.40	55.06	50.93	51.13	49.57	55.03	53.50	52.70	45.53	50.05	47.47	47.68
M₃	50.57	60.93	53.07	54.86	51.87	58.27	55.87	55.34	51.53	54.07	51.53	52.38
M₄	45.60	51.80	48.30	48.57	45.67	50.80	49.91	48.79	43.07	48.13	45.67	45.62
Mean	50.29	57.62	52.86		50.50	56.19	53.97		48.33	52.61	50.02	
	S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.04	0.06	0.17		0.019	0.02	0.075		0.014	0.019	0.06	
CD @ 5%	0.13	0.17	0.51		0.055	0.07	0.220		0.041	0.054	0.16	

Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm S ₃ :- 50 × 60 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	
	M ₂ :- Vermicompost @ 5 t/ha	M ₃ :- Poultry manure @ 4 t/ha M ₄ :- Neem cake @ 2 t/ha

Fig. 3 **Effect of spacing and organic manure on number of leaves of Indian spinach** (45, 75, 105,135,165,195 and 225DAS)



Treatment Details:		
Spacing	Organic manure	
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm S ₃ :- 50 × 60 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
	M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

The trend of various treatment combinations on number of leaves at 225 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_3M_1 > S_2M_3 > S_1M_1 > S_3M_3 > S_1M_3 > S_2M_2 > S_2M_4 > S_3M_2 > \\ S_3M_4 > S_1M_2 > S_1M_4$$

The highest number of leaves was recorded with treatment combinations S_2M_1 (50 × 45 cm spacing along with FYM @ 10 t/ha + 100:50:50 kg/ha NPK) might be due to favorable combination effect of spacing and organic manure on number of leaves of Indian spinach.

4.1.4 **Inter-nodal length** (cm):

4.1.4.1 **Effect of spacing** (S):

The data regarding effect of spacing on inter-nodal length are given in Table 6a and 6b. It was observed from the data that inter-nodal length affected significantly at 45, 75, 105, 135, 165, 195 and 225 days after sowing.

At 45 DAS, significantly highest inter-nodal length (1.81 cm) was recorded with treatment S_3 followed by S_2 (1.70 cm). However, the lowest inter-nodal length (1.46 cm) was recorded with treatment S_1 .

The trend of effect of spacing on inter-nodal length (cm) at 45 DAS in descending order is as follows,

$$\underline{S_3} > S_2 > S_1$$

At 75 DAS, significantly highest inter-nodal length (2.06 cm) was recorded with treatment S_3 and lowest inter-nodal length (1.71 cm) was recorded with treatment S_1 .

The trend of effect of spacing on inter-nodal length (cm) at 75 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 105 DAS, significantly highest inter-nodal length (2.66 cm) was recorded with treatment S_3 followed by S_1 (2.36 cm). The lowest inter-nodal length (1.79 cm) was recorded with treatment S_1 .

The trend of effect of spacing on inter-nodal length (cm) at 105 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 135 DAS, significantly highest inter-nodal length (2.52 cm) was observed with treatment S_3 followed by S_2 (2.39 cm) whereas, the lowest inter-nodal length (2.13 cm) was recorded in S_1 .

The trend of effect of spacing on inter-nodal length (cm) at 135 DAS in descending order was as follows,

$$S_3 > S_2 > S_1$$

At 165 DAS, significantly the highest inter-nodal length (2.62 cm) was recorded with treatment S_3 . However, the lowest inter-nodal length (2.30 cm) was found with treatment S_1 .

The trend of effect of spacing on inter-nodal length (cm) at 165 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 195 DAS, significantly highest inter-nodal length (2.54 cm) was recorded with treatment S_3 . However, the lowest inter-nodal length (2.25 cm) was observed with treatment S_1 .

The trend of effect of spacing on inter-nodal length (cm) at 195 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

Similarly at 225 DAS, significantly highest inter-nodal length (3.55 cm) was recorded with treatment S_3 . However, the lowest inter-nodal length (2.45 cm) was recorded in S_1 followed by S_1 (2.61 cm).

The trend of effect of spacing on inter-nodal length (cm) at 225 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

The highest inter-nodal length was recorded in wider spacing S_3 and the lowest was observed in (S_1) closer spacing. The highest inter-nodal length under S_3 spacing might be due to maximum availability of nutrient and less competition for resources than that of closer spacing hence, ultimately the distance between two nodes reduced drastically. Similar result was also reported by Kumar *et al.* (2011) in okra and Khale (2018) in amaranth.

4.1.4.2 **Effect of organic manure (M):**

The data regarding effect of organic manure on inter-nodal length of Indian spinach are presented in (Table 6a and 6b). The inter-nodal length of Indian spinach varied significantly among the different organic manure treatments at 45, 75, 105, 135, 165, 195 and 225 DAS.

At 45 DAS, significantly highest inter-nodal length (1.74 cm) was recorded with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK *i.e.* (M_1) which was at par with M_3 (1.73 cm). However, the lowest inter-nodal length (1.47 cm) was recorded with application neem cake @ 2 t/ha *i.e.* (M_4).

The trend of effect of organic manure on inter-nodal length (cm) at 45 DAS in descending order was as follows,

$$\underline{M_1} > \underline{M_3} > M_2 > M_4$$

At 75 DAS, significantly highest inter-nodal length (2.04 cm) was recorded with treatment M_1 followed by M_3 (1.98 cm). However, the lowest inter-nodal length (1.70 cm) was recorded in M_4 .

The trend of effect of organic manure on inter-nodal length (cm) at 75 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 105 DAS, significantly the highest inter-nodal length (2.49 cm) was recorded with treatment M_1 followed by M_3 (2.36 cm) and M_2 (2.22 cm). The lowest inter-nodal length (2.02 cm) was recorded in M_4 .

The trend of effect of organic manure on inter-nodal length (cm) at 105 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 135 DAS, significantly highest inter-nodal length (2.53 cm) was found with treatment M_1 followed by M_3 (2.42 cm). However, the lowest inter-nodal length (2.13 cm) was recorded with M_4 .

The trend of effect of organic manure on inter-nodal length (cm) at 135 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 165 DAS, significantly highest inter-nodal length (2.76 cm) was recorded with treatment M_1 followed by M_3 (2.53 cm)

whereas, the lowest inter-nodal length (2.20 cm) was recorded in M₄.

The trend of effect of organic manure on inter-nodal length (cm) at 165 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 195 DAS, significantly highest inter-nodal length (2.64 cm) was recorded with treatment M₁. However, the lowest inter-nodal length (2.14 cm) was recorded in M₄.

The trend of effect of organic manure on inter-nodal length (cm) at 195 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

Similarly at 225 DAS, significantly highest inter-nodal length (3.37 cm) was observed in M₁. However, the lowest inter-nodal length (2.54 cm) was recorded in M₄.

The trend of effect of organic manure on inter-nodal length (cm) at 225 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

The highest inter-nodal length was recorded in manure M₁ it might be due to increase availability of nitrogen, phosphorus and potassium to the plants at all growth stages through FYM, fetching the needs of plant throughout the cropping season.

4.1.4.3 **Interaction effect** (S × M):

The interaction effect between spacing and organic manure on inter-nodal length of Indian spinach was varied significantly at all growth stages *i. e.* 45, 75, 105, 135, 165, 195 and 225 DAS (Table 6a and 6b).

At 45 DAS, significantly highest inter-nodal length (1.89 cm) was recorded treatment combination S₃M₁ which was at par with S₃M₃ (1.85 cm). However, the lowest inter-nodal length (1.05 cm) was found treatment combination S₁M₄.

The trend of various treatment combinations on inter-nodal length at 45 DAS in descending order was as follow,

$$\underline{S_3M_1 > S_3M_3} > S_3M_2 > S_2M_1 > S_3M_4 > S_2M_3 > S_2M_2 > S_2M_4 = S_1M_3 > S_1M_2 > S_1M_1 > S_1M_4$$

At 75 DAS, significantly highest inter-nodal length (2.18 cm) was recorded with treatment combination S₃M₁ which was at par with S₃M₃ (2.13 cm) while, S₁M₄ recorded the lowest inter-nodal length (1.48 cm).

The trend of various treatment combinations on inter-nodal length at 75 DAS in descending order was as follow,

$$\underline{S_3M_1 > S_3M_3} > S_3M_2 > S_2M_1 > S_2M_3 > S_1M_1 > S_3M_4 > S_1M_3 > S_2M_4 > S_2M_2 = S_1M_2 > S_1M_4$$

At 105 DAS, significantly highest inter-nodal length (2.74 cm) was recorded with treatment combination S₃M₁ which was at par with S₃M₃ (2.72 cm). However, the lowest inter-nodal length (1.30 cm) was found in S₁M₄.

The trend of various treatment combinations on inter-nodal length at 105 DAS in descending order was as follow

$$\underline{S_3M_1 > S_3M_3} > S_2M_1 > S_3M_2 > S_3M_4 > S_2M_3 > S_2M_4 > S_2M_2 > S_1M_1 > S_1M_3 > S_1M_2 > S_1M_4$$

At 135 DAS, significantly highest inter-nodal length (2.67 cm) was recorded with treatment combination S₃M₁ which was at par with S₃M₃ (2.66 cm) whereas, the lowest inter-nodal length (1.93 cm) was observed in S₁M₄.

The trend of various treatment combinations on inter-nodal length at 135 DAS in descending order was as follow

$$\underline{S_3M_1} > \underline{S_3M_3} > S_2M_1 > S_3M_2 > S_2M_3 > S_2M_2 > S_3M_4 > S_1M_1 > S_1M_3 > S_2M_4 > S_1M_2 > S_1M_4$$

At 165 DAS, significantly highest inter-nodal length (3.13 cm) was recorded with treatment combination S₃M₁. However, lowest inter-nodal length (2.14 cm) was found in S₁M₄ which was at par with S₂M₄ (2.15 cm).

The trend of various treatment combinations on inter-nodal length at 165 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_2M_1 > S_2M_3 > S_1M_1 > S_1M_3 > S_3M_2 > S_3M_4 > S_2M_2 > S_1M_2 > \underline{S_2M_4} > \underline{S_1M_4}$$

At 195 DAS, significantly highest inter-nodal length (2.86 cm) was observed with treatment combination S₃M₁ followed by S₃M₃ (2.76 cm) and S₂M₁ (2.65 cm) whereas, the lowest inter-nodal length (2.05 cm) was recorded in S₁M₄.

The trend of various treatment combinations on inter-nodal length at 195 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_2M_1 > S_3M_2 > S_1M_1 > S_3M_3 > S_1M_3 > S_3M_4 > S_2M_2 > S_1M_2 > S_3M_4 > S_1M_4$$

Table: 6a **Effect of spacing and organic manure on inter-nodal length (cm) of Indian spinach**
(45, 75, 105 and 135 DAS)

Inter-nodal length (cm)																
Treatment	45 DAS				75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	1.57	1.76	1.89	1.74	1.91	2.03	2.18	2.04	2.08	2.64	2.74	2.49	2.29	2.64	2.67	2.53
M₂	1.58	1.70	1.78	1.69	1.64	1.64	2.09	1.79	1.84	2.19	2.62	2.22	2.08	2.36	2.44	2.29
M₃	1.64	1.71	1.85	1.73	1.81	1.99	2.13	1.98	1.96	2.39	2.72	2.36	2.22	2.38	2.66	2.42
M₄	1.05	1.64	1.73	1.47	1.48	1.77	1.84	1.70	1.30	2.20	2.56	2.02	1.93	2.16	2.31	2.13
Mean	1.46	1.70	1.81		1.71	1.86	2.06		1.79	2.36	2.66		2.13	2.39	2.52	
	S	M	S × M		S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.004	0.005	0.016		0.007	0.009	0.027		0.006	0.008	0.024		0.0009	0.0011	0.003	
CD @ 5%	0.012	0.016	0.048		0.019	0.026	0.078		0.018	0.024	0.071		0.0025	0.0034	0.010	

Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	
S ₃ :- 50 × 60 cm	M ₂ :- Vermicompost @ 5 t/ha	M ₃ :- Poultry manure @ 4 t/ha
		M ₄ :- Neem cake @ 2 t/ha

Table: 6b **Effect of spacing and organic manure on inter-nodal length (cm) of Indian spinach**
(165, 195 and 225 DAS)

Inter-nodal length (cm)												
Treatment	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	2.43	2.71	3.13	2.76	2.42	2.65	2.86	2.64	2.83	3.15	4.13	3.37
M₂	2.21	2.24	2.31	2.25	2.20	2.26	2.44	2.30	2.33	2.43	3.41	2.72
M₃	2.41	2.46	2.73	2.53	2.33	2.39	2.76	2.49	2.46	2.57	3.48	2.84
M₄	2.14	2.15	2.31	2.20	2.05	2.29	2.08	2.14	2.19	2.28	3.16	2.54
Mean	2.30	2.39	2.62		2.25	2.40	2.54		2.45	2.61	3.55	
	S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.0009	0.0012	0.004		0.0006	0.0009	0.0026		0.0008	0.001	0.003	
CD @ 5%	0.0026	0.0035	0.010		0.0019	0.0025	0.0076		0.0023	0.003	0.009	

Treatment Details:		
Spacing	Organic manure	
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
S ₃ :- 50 × 60 cm	M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

Significantly highest inter-nodal length (4.13 cm) was recorded in S₃M₁ at 225 DAS and it was found significantly superior over rest of the treatments. The lowest inter-nodal length (2.19 cm) was recorded with treatment combination S₁M₄.

The trend of various treatment combinations on inter-nodal length at 225 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_3M_2 > S_3M_4 > S_2M_1 > S_1M_1 > S_2M_3 > S_1M_3 > S_2M_2 > \\ S_1M_2 > S_2M_4 > S_1M_4$$

The highest inter-nodal length was recorded with treatment combinations S₃M₁ (50 × 60 cm spacing along with FYM @ 10 t/ha + 100:50:50 kg/ha NPK) might be due to favorable combination effect of spacing and organic manure on number of leaves of Indian spinach.

4.1.5 **Number of branches:**

Number of branches per plant is important character of Indian spinach plant responsible for the increase in yield per plant and indicates the form of the plant. Variation in branches per plant of Indian spinach are presented in Table 7a and 7b.

4.1.5.1 **Effect of spacing (S)**

The data regarding effect of spacing on number of branches are given in Table 7a and 7b. It was observed from the data that number of branches affected significantly at all growth stages except 45 DAS.

At 45 DAS, effect of spacing was found non-significant. The highest number of branches (0.25) was recorded with treatment S₂ whereas, the lowest number of branches was recorded with treatment S₁.

The trend of effect of spacing on number of branches at 45 DAS in descending order is as follows,

$$\underline{S_2} > S_1 > S_3$$

At 75 DAS, significantly highest number of branches (4.57) was recorded with treatment S_2 . However, the lowest number of branches (3.51) was recorded with S_3 .

The trend of effect of spacing on number of branches at 75 DAS in descending order was as follows,

$$\underline{S_2} > S_1 > S_3$$

At 105 DAS, significantly highest number of branches (5.35) was recorded with treatment S_2 . Whereas, the lowest number of branches (4.20) was recorded in spacing S_3 .

The trend of effect of spacing on number of branches at 105 DAS in descending order was as follows,

$$\underline{S_2} > S_1 > S_3$$

At 135 DAS, significantly highest number of branches (7.68) was observed with treatment S_2 followed by S_3 (7.34) and lowest number of branches (6.26) was recorded in S_1 .

The trend of effect of spacing on number of branches at 135 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 165 DAS, significantly highest number of branches (9.36) was found with spacing 50×45 cm. However, the lowest number of branches (7.89) was found with spacing 50×30 cm.

The trend of effect of spacing on number of branches at 165 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 195 DAS, significantly highest number of branches (10.38) was recorded with treatment S₂ and lowest number of branches (9.06) was recorded with treatment S₁.

The trend of effect of spacing on number of branches at 195 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 225 DAS, the highest number of branches (12.47) was recorded with treatment S₂ and it was found significantly superior. However, the lowest number of branches (9.41) was found in S₁.

The trend of effect of spacing on number of branches at 225 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

The highest number of branches with respect to spacing was recorded in optimum spacing 50 × 45 cm might be due to optimum plant population with results in optimum space available for plant growth as well as availability of nutrients, light, soil moisture and aeration. Similar results with respect to spacing obtained by Islam *et al.* (2014), in Indian spinach. Also, similar results were reported by Sharma *et al.* (2001) in okra, Malligawad and Patil (2001), Chaudhari *et al.* (2009), Joseph *et al.* (2009) and Abothula (2012) in amaranth, Bairagi (2014) in fenugreek.

4.1.5.2 **Effect of organic manure (M):**

The data regarding effect of organic manure on number of branches of Indian spinach are presented in (Table 7a and 7b). The number of branches of Indian spinach varied significantly

among the different organic manure treatments at 75, 105, 135, 165, 195 and 225 DAS except 45 DAS.

At 45 days, the effect of organic manure on number of branches of Indian spinach was non-significant. The range varied from 0.00 to 0.33.

The trend of effect of organic manure on number of branches at 45 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

At 75 DAS, significantly highest number of branches (4.28) was recorded with treatment M_1 followed by M_3 (4.17) whereas, the lowest number of branches (3.75) was recorded with treatment M_4 .

The trend of effect of organic manure on number of branches at 75 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 105 DAS, significantly highest number of branches (5.03) was recorded with treatment M_1 . However, the lowest number of branches (4.47) was recorded with treatment M_4 .

The trend of effect of organic manure on number of branches at 105 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 135 DAS, significantly highest number of branches (7.55) was found with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK (M_1) and it was found significantly superior over rest of the organic manure treatments. However, the lowest number of branches (6.54) was recorded with application of neem cake @ 2 t/ha (M_4).

The trend of effect of organic manure on number of branches at 135 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 165 DAS, significantly highest number of branches (9.08) was recorded with treatment M_1 and lowest number of branches (8.16) was recorded with treatment M_4 .

The trend of effect of organic manure on number of branches at 165 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

At 195 DAS, the highest number of branches (10.43) was recorded with treatment M_1 and it was found significantly superior over rest of the treatments. However, the lowest number of branches (9.19) was recorded with treatment M_4 .

The trend of effect of organic manure on number of branches at 195 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 225 DAS, significantly highest number of branches (11.72) was observed in M_1 (FYM @ 10 t/ha + 100:50:50 kg/ha NPK) followed by M_3 (11.57). However, the lowest number of branches (10.79) was recorded in M_4 (Neem cake @ 2 t/ha).

The trend of effect of organic manure on number of branches at 225 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

The highest number of branches reported with application of FYM @ 10 t/ha + 100:50:50 kg NPK/ha might be due to optimum availability of essential nutrients (both major and

minor). Further, the beneficial role of FYM in improving physico-chemical as well as biological property of soil which resulted in favorable condition for absorption of essential nutrients by plants. Similar results with respect to organic manure obtained by Hisham *et al.* (2014), Miglani *et al.* (2017), Ola *et al.* (2018) in okra.. This might be attributed to multifarious role of FYM and NPK in supply of nutrients as well as improvement in physical, chemical and biological environment of soil. Finally, it was reflected in better growth of plant with FYM.

4.1.5.3 **Interaction effect** (S × M):

The interaction effect between spacing and organic manure on number of branches of Indian spinach was varied significantly at all growth stages except 45 DAS (Table 7a and 7b).

The interaction effect between spacing and organic manure on number of branches of Indian spinach at 45 DAS was non-significant. The range varied from 0.00 to 0.67.

At 75 DAS, significantly highest number of branches (4.83) was recorded with treatment combination S₂M₁ while, S₃M₄ recorded the lowest number of branches (3.20).

The trend of various treatment combinations on number of branches at 75 DAS in descending order was as follow,

$$S_2M_1 > S_2M_3 > S_2M_2 > S_1M_1 > S_2M_4 > S_1M_3 > S_1M_2 > S_1M_4 > S_3M_1 > S_3M_3 > S_3M_2 > S_3M_4$$

At 105 DAS, significantly highest number of branches (5.67) was recorded with treatment combination S₂M₁. The lowest number of branches (3.38) was recorded with treatment combination S₃M₄.

The trend of various treatment combinations on number of branches at 105 DAS in descending order was as follow

$$\underline{S_2M_1} > S_2M_3 > S_2M_2 > S_2M_4 > S_1M_1 > S_1M_3 > S_1M_2 > S_1M_4 > S_3M_1 > S_3M_2 > S_3M_3 > S_3M_4$$

At 135 DAS, significantly highest number of branches (8.03) was recorded with treatment combination S_2M_1 while, the lowest number of branches (5.53) was observed in S_1M_4 .

The trend of various treatment combinations on number of branches at 135 DAS in descending order was as follow

$$\underline{S_2M_1} > S_2M_3 > S_3M_1 > S_2M_2 > S_3M_3 > S_2M_4 > S_3M_2 > S_3M_4 > S_1M_1 > S_1M_3 > S_1M_2 > S_1M_4$$

At 165 DAS, significantly highest number of branches (9.74) was recorded with treatment combination S_2M_1 followed by S_2M_3 (9.53) and lowest number of branches (7.48) was recorded in S_1M_4 .

The trend of various treatment combinations on number of branches at 165 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_2M_3 > S_3M_1 > S_3M_3 > S_2M_2 > S_3M_2 > S_2M_4 > S_1M_1 > S_1M_3 > S_1M_2 > S_3M_4 > S_1M_4.$$

At 195 DAS, significantly highest number of branches (10.88) was recorded with treatment combination S_2M_1 followed by S_3M_1 (10.55) and S_2M_3 (10.40). The lowest number of branches (8.33) was recorded in S_1M_4 .

The trend of various treatment combinations on number of branches at 195 DAS in descending order was as follow,

Table: 7a **Effect of spacing and organic manure on number of branches of Indian spinach**
(45, 75, 105 and 135 DAS)

Number of branches																
Treatment	45 DAS				75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	0.33	0.67	0.00	0.33	4.35	4.83	3.67	4.28	5.06	5.67	4.36	5.03	6.77	8.03	7.86	7.55
M₂	0.00	0.00	0.00	0.00	3.93	4.42	3.54	3.96	4.37	5.29	4.26	4.64	6.14	7.47	7.19	6.93
M₃	0.33	0.33	0.00	0.22	4.20	4.69	3.62	4.17	4.76	5.37	4.19	4.77	6.60	7.96	7.45	7.34
M₄	0.00	0.00	0.00	0.00	3.71	4.34	3.20	3.75	4.36	5.08	3.38	4.47	5.53	7.25	6.85	6.54
Mean	0.17	0.25	0.00		4.05	4.57	3.51		4.64	5.35	4.20		6.26	7.68	7.34	
	S	M	S × M		S	M	S × M		S	M	S × M		S	M	S × M	
F test	NS	NS	NS		Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.E.m.±	0.10	0.10	0.17		0.0014	0.0019	0.006		0.011	0.02	0.05		0.0014	0.002	0.006	
CD @ 5%	-	-	-		0.0041	0.0054	0.016		0.033	0.04	0.13		0.0041	0.005	0.016	

Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm ,	S ₂ :- 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK
S ₃ :- 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha
		M ₃ :- Poultry manure @ 4 t/ha
		M ₄ :- Neem cake @ 2 t/ha

Table: 7b **Effect of spacing and organic manure on number of branches of Indian spinach**
(165, 195 and 225 DAS)

Treatment	Number of branches											
	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	8.15	9.74	9.36	9.08	9.86	10.88	10.55	10.43	10.07	12.74	12.36	11.72
M₂	7.85	9.23	9.05	8.71	8.42	10.22	9.55	9.40	8.88	12.43	11.89	11.07
M₃	8.07	9.53	9.24	8.95	9.63	10.40	9.89	9.97	9.92	12.57	12.22	11.57
M₄	7.48	8.94	8.06	8.16	8.33	10.03	9.21	9.19	8.77	12.13	11.48	10.79
Mean	7.89	9.36	8.93		9.06	10.38	9.80		9.41	12.47	11.99	
	S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.014	0.019	0.056		0.014	0.019	0.056		0.0004	0.0006	0.0017	
CD @ 5%	0.041	0.054	0.163		0.041	0.054	0.163		0.0012	0.0016	0.0049	

Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm S ₃ :- 50 × 60 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	
	M ₂ :- Vermicompost @ 5 t/ha	
	M ₃ :- Poultry manure @ 4 t/ha	
	M ₄ :- Neem cake @ 2 t/ha	

$$S_2M_1 > S_3M_1 > S_2M_3 > S_2M_2 = S_3M_3 > S_2M_4 > S_1M_1 > S_1M_3 > S_3M_2 > \\ S_3M_4 > S_1M_2 > S_1M_4.$$

At 225 DAS, significantly highest number of branches (12.74) was recorded with treatment combination S_2M_1 . Whereas, the lowest number of branches (8.77) was recorded in S_1M_4 .

The trend of various treatment combinations on number of branches at 225 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_2M_3 > S_2M_2 > S_3M_1 > S_3M_3 > S_2M_4 > S_3M_2 > S_3M_4 > S_1M_1 > \\ S_1M_3 > S_1M_2 > S_1M_4$$

The highest number of branches was recorded with treatment combinations S_2M_1 (50 × 45 cm spacing along with FYM @ 10 t/ha + 100:50:50 kg/ha NPK) might be due to favorable combination effect of spacing and organic manure on number of branches of Indian spinach.

4.1.6 **Leaf area** (cm²):

4.1.6.1 **Effect of spacing** (S):

The data regarding effect of spacing on leaf area are given in Table 8a and 8b. It was observed from the data that leaf area affected significantly at 45, 75, 105, 135, 165, 195 and 225 days after sowing.

At 45 DAS, significantly highest leaf area (114.29 cm²) was recorded with treatment S_2 and it was found significantly superior over rest of all the spacing levels. However, the lowest leaf area (92.06 cm²) was recorded with treatment S_1 .

The trend of effect of spacing on leaf area at 45 DAS in descending order is as follows,

$$\underline{S_2} > S_3 > S_1$$

At 75 DAS, significantly highest leaf area (192.76 cm²) was observed with treatment S₂. However, the lowest leaf area (172.38 cm²) was recorded with treatment S₁.

The trend of effect of spacing on leaf area at 75 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 105 DAS, significantly highest leaf area (230.48 cm²) was recorded with treatment S₂. Whereas, the lowest leaf area (213.36 cm²) was recorded with treatment S₁.

The trend of effect of spacing on leaf area at 105 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 135 DAS, the highest leaf area (238.93 cm²) was observed with treatment S₂ and it was found significantly superior. However, the lowest leaf area (219.19 cm²) was recorded in spacing S₁.

The trend of effect of spacing on leaf area at 135 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 165 DAS, the highest leaf area (237.50 cm²) was recorded with spacing 50 × 45 cm and the lowest leaf area (211.75 cm²) was recorded with spacing 50 × 30 cm.

The trend of effect of spacing on leaf area at 165 DAS in descending order was as follows,

$$S_2 > S_3 > S_1$$

At 195 DAS, significantly highest leaf area (231.07 cm²) was recorded with treatment S₂. However, the lowest leaf area (202.51 cm²) was recorded with treatment S₁.

The trend of effect of spacing on leaf area at 195 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

At 225 DAS, the highest leaf area (238.82 cm²) was recorded with treatment S₂ and it was found significantly superior over rest of the spacing levels. However, the lowest leaf area (215.51 cm²) was found in S₁.

The trend of effect of spacing on leaf area at 225 DAS in descending order was as follows,

$$\underline{S_2} > S_3 > S_1$$

The maximum leaf area with respect to spacing was recorded in S₂ might be due to optimum plant population, consumption for light and optimum space available for plant growth. Similar results with respect to spacing obtained by Choudhary *et al.* (2004) in palak, Smitha *et al.* (2011), Abothula (2012) and Prasanna (2019) in amaranth, Sharma *et al.* (2013) in radish and Lavanya *et al.* (2017) in radish.

4.1.6.2 **Effect of organic manure (M):**

The data regarding effect of organic manure on leaf area of Indian spinach are presented in (Table 8a and 8b). The leaf area of Indian spinach varied significantly among the different organic manure treatments at 45, 75, 105, 135, 165, 195 and 225 DAS.

At 45 DAS, significantly highest leaf area (120.33 cm²) was recorded with treatment M₁ and it was found significantly

superior over rest of the organic manure treatments. However, the lowest leaf area (85.17 cm²) was recorded with treatment M₄.

The trend of effect of organic manure on leaf area at 45 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 75 DAS, the highest leaf area (193.78 cm²) was recorded with treatment M₁ and it was found significantly superior. However, the lowest leaf area (169.82 cm²) was recorded with treatment M₄.

The trend of effect of organic manure on leaf area at 75 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 105 DAS, significantly highest leaf area (234.58 cm²) was recorded with treatment M₁ and lowest leaf area (210.05 cm²) was recorded in M₄.

The trend of effect of organic manure on leaf area at 105 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 135 DAS, significantly highest leaf area (246.77 cm²) was found with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK whereas, the lowest leaf area (215.54 cm²) was recorded with application of neem cake @ 2 t/ha.

The trend of effect of organic manure on leaf area at 135 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 165 DAS, the highest leaf area (251.20 cm²) was recorded with treatment M₁ and it was found significantly superior. The lowest leaf area (206.47 cm²) was recorded in M₄.

The trend of effect of organic manure on leaf area at 165 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 195 DAS, significantly highest leaf area (233.42 cm²) was recorded with treatment M₁ and lowest leaf area (195.43 cm²) was recorded in M₄.

The trend of effect of organic manure on leaf area at 195 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 225 DAS, significantly highest leaf area (240.15 cm²) was observed with treatment M₁. However, the lowest leaf area (213.73 cm²) was recorded with treatment M₄.

The trend of effect of organic manure on leaf area at 225 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

The maximum leaf area with respect to organic manure reported with treatment M₁ can be attributed to higher availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizers fulfilling the needs of plant throughout the cropping season. The similar trends of also been represented in interaction effect of spacing and organic manure. Similar results with respect to organic manure obtained by Sannigrahi and Borach (2001) and Premsekhar and Rajashree (2009) in okra Kushare *et al.* (2010) and Sanni (2016) in amaranth, Ullah *et al.* (2017) in lettuce. This

might be attributed to multifarious role of FYM and NPK in supply of nutrients as well as improvement in physical, chemical and biological environment of soil. Finally, it was reflected in better growth of plant with FYM.

4.1.6.3 **Interaction effect** (S × M):

The interaction effect of spacing and organic manure on leaf area of Indian spinach exhibited similar trend and it was varied significantly at all growth stages (45, 75, 105, 135, 165, 195 and 225 DAS). (Table 8a and 8b and fig. 4).

At 45 DAS, significantly highest leaf area (137.17 cm²) was recorded with treatment combination S₂M₁ whereas, the lowest leaf area (78.67 cm²) was recorded with treatment combination S₁M₄.

The trend of various treatment combinations on leaf area at 45 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_3M_1 > S_2M_3 > S_1M_1 > S_2M_2 > S_1M_3 > S_2M_4 > S_3M_3 > S_1M_2 > S_3M_2 > S_1M_4 > S_3M_4$$

At 75 DAS, the highest leaf area (206.31 cm²) was recorded with treatment combination S₂M₁ and it was found significantly superior while, S₁M₄ recorded the lowest leaf area (162.09 cm²).

The trend of various treatment combinations on leaf area at 75 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_2M_3 > S_3M_1 > S_2M_2 > S_3M_3 > S_1M_1 > S_2M_4 > S_3M_2 > S_1M_3 > S_3M_4 > S_1M_2 > S_1M_4$$

At 105 DAS, significantly highest leaf area (243.31 cm²) was recorded with treatment combination S₂M₁. The lowest leaf area (201.74 cm²) was recorded with S₁M₄.

The trend of various treatment combinations on leaf area at 105 DAS in descending order was as follow

$$\underline{S_2M_1} > S_3M_1 > S_2M_3 > S_3M_3 > S_2M_2 > S_1M_1 > S_3M_2 > S_2M_4 > S_1M_3 > \\ S_1M_2 > S_3M_4 > S_1M_4$$

At 135 DAS, significantly highest leaf area (254.23 cm²) was recorded with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK along with spacing 50 × 45 cm followed by S₃M₁ (252.44 cm²). However the lowest leaf area (205.51 cm²) was observed with application of neem cake @ 2 t/ha along with spacing 50 × 30 cm.

The trend of various treatment combinations on leaf area at 135 DAS in descending order was as follow

$$\underline{S_2M_1} > S_3M_1 > S_3M_3 > S_3M_2 > S_1M_1 > S_2M_3 > S_3M_4 > S_2M_2 > S_1M_3 > \\ S_2M_4 > S_1M_2 > S_1M_4$$

At 165 DAS, significantly highest leaf area (262.23 cm²) was recorded with treatment combination S₂M₁. However, lowest leaf area (192.56 cm²) was recorded in S₁M₄.

The trend of various treatment combinations on leaf area at 165 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_3M_1 > S_2M_3 > S_1M_1 > S_1M_3 > S_3M_3 > S_2M_2 > S_2M_4 > S_3M_2 > \\ S_3M_4 > S_1M_2 > S_1M_4$$

At 195 DAS, significantly highest leaf area (246.22 cm²) was recorded with treatment combination S₂M₁ and the lowest leaf area (179.55 cm²) was recorded with treatment combination S₁M₄.

Table: 8a **Effect of spacing and organic manure on leaf area (cm²) of Indian spinach (45, 75, 105 and 135 DAS)**

Leaf area (cm ²)																
Treat ment	45 DAS				75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	108.90	137.17	114.91	120.33	183.83	206.31	191.21	193.78	223.47	243.31	236.97	234.58	233.64	254.23	252.44	246.77
M₂	86.68	107.90	90.13	94.90	166.95	188.59	177.87	177.80	210.66	225.02	219.48	218.39	215.19	235.29	224.00	224.83
M₃	93.99	117.24	99.90	103.71	176.65	197.25	186.91	186.94	217.56	235.09	226.44	226.36	222.42	240.38	231.36	231.39
M₄	78.67	94.83	82.02	85.17	162.09	178.88	168.48	169.82	201.74	218.51	209.91	210.05	205.51	225.83	215.27	215.54
Mean	92.06	114.29	96.74		172.38	192.76	181.12		213.36	230.48	223.20		219.19	238.93	230.77	
	S	M	S × M		S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.14	0.19	0.56		0.014	0.019	0.06		0.042	0.06	0.17		0.024	0.03	0.10	
CD @ 5%	0.41	0.54	1.63		0.041	0.054	0.16		0.122	0.16	0.49		0.071	0.09	0.28	

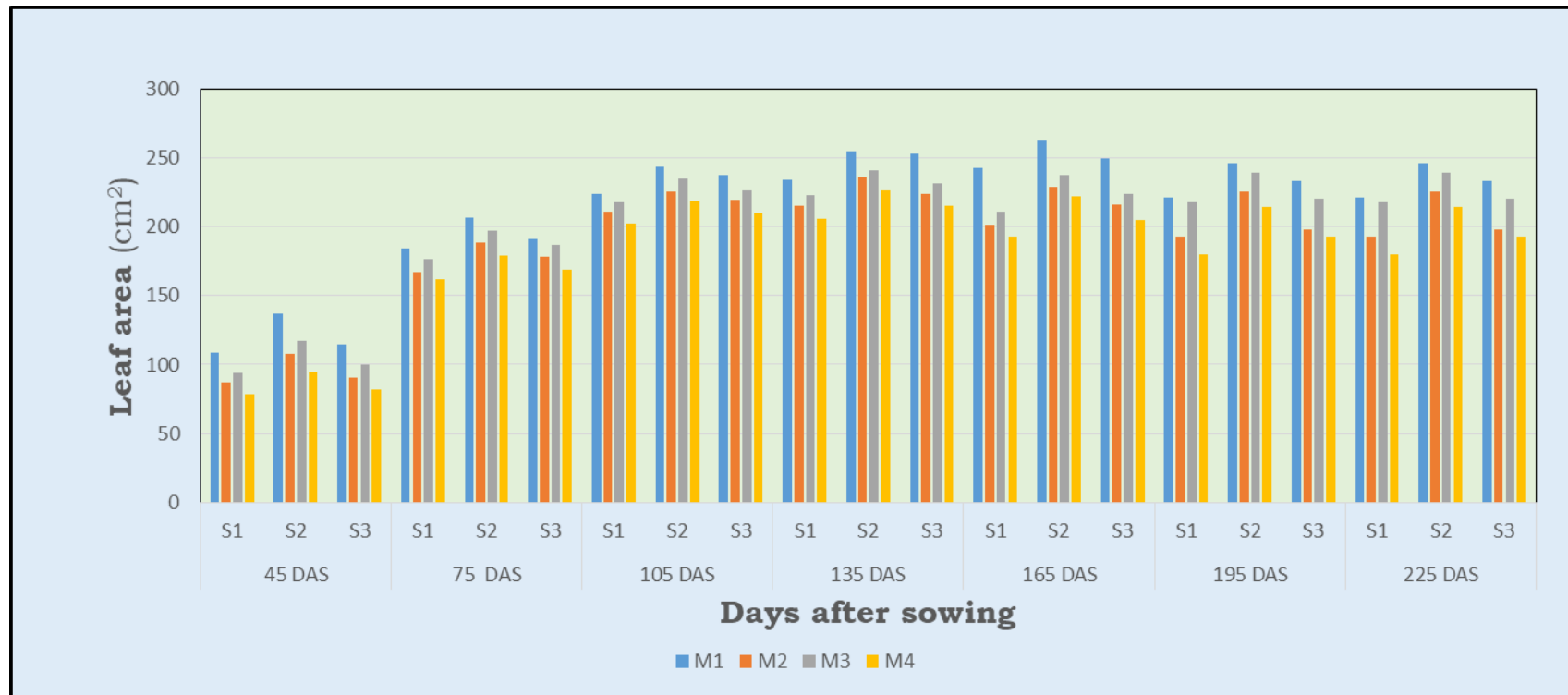
Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm ,	S ₂ :- 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK
S ₃ :- 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha
		M ₃ :- Poultry manure @ 4 t/ha
		M ₄ :- Neem cake @ 2 t/ha

Table: 8b **Effect of spacing and organic manure on leaf area (cm²) of Indian spinach (165, 195 and 225 DAS)**

Leaf area (cm ²)												
Treatment	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	242.06	262.23	249.32	251.20	220.85	246.22	233.18	233.42	224.95	253.32	242.17	240.15
M₂	201.60	228.59	215.92	215.37	192.42	224.93	197.50	204.95	211.87	234.66	221.70	222.74
M₃	210.76	237.11	223.45	223.78	217.23	238.99	220.51	225.58	217.61	248.50	231.31	232.47
M₄	192.56	222.05	204.80	206.47	179.55	214.15	192.59	195.43	207.60	218.80	214.78	213.73
Mean	211.75	237.50	223.37		202.51	231.07	210.94		215.51	238.82	227.49	
	S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.05	0.07	0.20		0.12	0.16	0.48		0.15	0.20	0.60	
CD @ 5%	0.15	0.20	0.59		0.36	0.47	1.42		0.44	0.58	1.75	

Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm S ₃ :- 50 × 60 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	
	M ₂ :- Vermicompost @ 5 t/ha	M ₃ :- Poultry manure @ 4 t/ha M ₄ :- Neem cake @ 2 t/ha

Fig. 4 **Effect of spacing and organic manure on leaf area (cm²) of Indian spinach** (45, 75, 105, 135,165, 195 and 225 DAS)



Treatment Details:		
Spacing	Organic manure	
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
S ₃ :- 50 × 60 cm	M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

The trend of various treatment combinations on leaf area at 195 DAS in descending order was as follow,

$$S_2M_1 > S_3M_1 > S_2M_3 > S_1M_1 > S_1M_3 > S_3M_3 > S_2M_2 > S_2M_4 > S_3M_2 > \\ S_3M_4 > S_1M_2 > S_1M_4$$

At 225 DAS, significantly highest leaf area (253.32 cm²) was recorded with treatment combination S₂M₁. The lowest leaf area (207.60 cm²) was recorded in treatment S₁M₄.

The trend of various treatment combinations on leaf area at 225 DAS in descending order was as follow,

$$\underline{S_2M_1} > S_3M_1 > S_2M_3 > S_1M_1 > S_1M_3 > S_3M_3 > S_2M_2 > S_2M_4 > S_3M_2 > \\ S_3M_4 > S_1M_2 > S_1M_4$$

The highest leaf area was recorded with treatment combinations S₂M₁ (50 × 45 cm spacing along with FYM @ 10 t/ha + 100:50:50 kg/ha NPK) might be due to favorable combination effect of spacing and organic manure on leaf area of Indian spinach.

4.2 Yield attributing characters:

Yield is central character of any crop experiment. Yield per plant is one of the most important yield attributing character related with ultimate return from per hectare. Variation in yield parameter was observed among the different spacing, organic manure and their interactions.

4.2.1 Herbage yield per plant (g)

The data pertaining to the herbage yield per plant (g) of Indian spinach are presented in Table 9a and 9b.

4.2.1.1 **Effect of spacing (S):**

The data regarding effect of spacing on herbage yield per plant are given in Table 9a and 9b. It was observed from the data that herbage yield per plant affected significantly at 45, 75, 105, 135, 165, 195 and 225 days after sowing.

At 45 DAS, significantly highest herbage yield per plant (21.63 g) was recorded with treatment S₃ while, lowest herbage yield per plant (19.40 g) was recorded in S₁.

The trend of effect of spacing on herbage yield per plant (g) at 45 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 75 DAS, significantly highest herbage yield was observed with treatment S₃ (52.95 g) followed by S₂ (52.66 g). However, the lowest herbage yield per plant (51.94 g) was recorded with treatment S₁.

The trend of effect of spacing on herbage yield per plant (g) at 75 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 105 DAS, significantly highest herbage yield (69.14 g) was recorded with treatment S₃. The lowest herbage yield (68.67 g) was recorded with treatment S₁.

The trend of effect of spacing on herbage yield per plant (g) at 105 DAS in descending order is as follows,

$$\underline{S_3} > S_2 > S_1$$

At 135 DAS, significantly highest herbage yield (78.18 g) was recorded with wider spacing 50 × 60 cm and it was

significantly superior. However, the lowest herbage yield per plant (75.63 g) was recorded with closer spacing 50 × 30 cm.

The trend of effect of spacing on herbage yield at 135 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 165 DAS, significantly highest herbage yield per plant (88.38 g) was recorded with treatment S_3 . However, the lowest herbage yield per plant (85.04 g) was recorded in S_1 .

The trend of effect of spacing on herbage yield per plant at 165 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 195 DAS, significantly highest herbage yield per plant (95.95 g) was recorded with treatment S_3 followed by S_2 (95.75 g) whereas, the lowest herbage yield per plant (93.89 g) was recorded with treatment S_1 .

The trend of effect of spacing on herbage yield per plant at 195 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

At 225 DAS, significantly highest herbage yield per plant (109.71 g) was recorded with treatment S_3 followed by S_2 (109.13 g) while, the lowest herbage yield per plant (107.74 g) was recorded with treatment S_1 .

The trend of effect of spacing on herbage yield per plant at 225 DAS in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

The highest herbage yield per plant was recorded in wider spacing S₃ and the lowest herbage yield per plant was observed in (S₁) closer spacing. From this results it was observed that plant spacing S₃ provided enough opportunity for the plant to receive maximum nutrient, aeration and sunlight as a result maximum photosynthesis could occur. For that maximum growth was attained and maximum foliage coverage with highest number and yield per plant of Indian spinach was found. Similar results were also reported by Yoshizawa *et al.* (1981) in stem amaranth, Sharma *et al.* (2001) in lettuce and Mane *et al.* (2008) in spinach.

4.2.7.2 **Effect of organic manure (M):**

The data regarding effect of organic manure on herbage yield per plant of Indian spinach are presented in (Table 9a and 9b). The herbage yield per plant of Indian spinach varied significantly among the different organic manure treatments at 45, 75, 105, 135, 165, 195 and 225 DAS.

At 45 DAS, significantly highest herbage yield per plant (21.47 g) was recorded with treatment M₁ followed by M₃ (21.02 g). However, the lowest herbage yield per plant (19.75 g) was recorded with treatment M₄.

The trend of effect of organic manure on herbage yield per plant at 45 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 75 DAS, significantly highest herbage yield per plant (53.30 g) was recorded with treatment M₁. The lowest herbage yield per plant (51.42 g) was recorded with treatment M₄.

The trend of effect of organic manure on herbage yield per plant at 75 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 105 DAS, significantly highest herbage yield per plant (69.48 g) was recorded with M_1 followed by M_3 (69.20 g). The lowest herbage yield per plant (68.38 g) was recorded in M_4 .

The trend of effect of organic manure on herbage yield per plant at 105 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 135 DAS, significantly highest herbage yield per plant (77.43 g) was recorded with treatment M_1 followed by M_3 (77.25 g) and M_2 . (77.11 g). However, the lowest herbage yield per plant (77.01 g) was recorded in treatment M_4 .

The trend of effect of organic manure on herbage yield per plant at 135 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 165 DAS, significantly highest herbage yield per plant (87.30 g) was recorded with treatment M_1 followed by M_3 (87.16 g) and lowest herbage yield per plant (86.43 g) was recorded in M_4 .

The trend of effect of organic manure on herbage yield per plant at 165 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

Similarly at 195 DAS, significantly highest herbage yield per plant (95.59 g) was recorded with treatment M_1 followed by M_3 (95.38 g) while, the lowest herbage yield per plant (94.74 g) was recorded with treatment M_4 .

The trend of effect of organic manure on herbage yield per plant at 195 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 225 DAS, significantly highest herbage yield per plant (109.49 g) was observed with treatment M_1 followed by M_3 (109.17 g). However, the lowest herbage yield per plant (108.28 g) was recorded with treatment M_4 .

The trend of effect of organic manure on herbage yield per plant at 225 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

The highest herbage yield per plant was recorded in M_1 , while, the lowest (M_4). The highest herbage yield per plant was recorded with treatment M_1 might be due to higher availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizer fulfilling the needs of plant throughout the cropping season. The above findings have shown similarities with the result reported by Padmanabha *et al.* (2009) in palak, Umesha *et al.* (2011) in brinjal, Premsekhar and Rajashree (2009) and Ola *et al.* (2018) in okra and Hashimi *et.al* (2019) in spinach

4.2.1.3. **Interaction effect** ($S \times M$):

The interaction effect between spacing and organic manure on herbage yield per plant of Indian spinach was varied significantly at all growth stages (Table 9a and 9b).

At 45 DAS, significantly highest herbage yield per plant (22.27 g) was recorded with treatment combination S_3M_1 while, lowest herbage yield per plant (18.59 g) was recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on herbage yield per plant at 45 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_2M_1 > S_3M_2 > S_2M_3 > S_3M_4 > S_2M_2 > S_1M_1 > S_2M_4 > \\ S_1M_3 > S_1M_2 > S_1M_4$$

At 75 DAS, significantly highest herbage yield per plant (53.92 g) was recorded with treatment combination S_3M_1 while, S_1M_4 recorded the lowest herbage yield per plant (51.28 g) which was at par with S_2M_4 (51.31 g).

The trend of various treatment combinations on herbage yield per plant at 75 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_2M_1 > S_2M_3 > S_2M_2 > S_3M_2 > S_1M_1 \quad S_1M_3 > S_1M_2 > \\ S_3M_4 > \underline{S_2M_4} > \underline{S_1M_4}$$

At 105 DAS, significantly highest herbage yield per plant (69.96 g) was recorded with treatment combination S_3M_1 followed by S_3M_3 (69.61 g), S_2M_1 (69.33 g), S_2M_3 (69.32 g) and (69.15 g) whereas, the lowest herbage yield per plant (68.32 g) was recorded in S_1M_4 .

The trend of various treatment combinations on herbage yield per plant at 105 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_2M_1 > S_2M_3 > S_1M_1 > S_1M_3 > S_1M_2 \quad S_3M_2 > S_3M_4 = \\ S_2M_2 > S_2M_4 > S_1M_4$$

At 135 DAS, significantly highest herbage yield per plant (78.31 g) was recorded with treatment combinations S_3M_1 . However, the lowest herbage yield per plant (75.41 g) was recorded in S_1M_4 .

The trend of various treatment combinations on herbage yield per plant at 135 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_2M_1 > S_3M_2 > S_3M_4 > S_2M_3 > S_2M_2 > S_2M_4 > S_1M_1 > S_1M_3 > S_1M_2 > S_1M_4$$

At 165 DAS, significantly highest herbage yield per plant (88.57 g) was recorded with treatment combinations S_3M_1 . However, the lowest herbage yield per plant (84.46 g) was recorded in S_1M_4 .

The trend of various treatment combinations on herbage yield per plant at 165 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_3M_2 > S_3M_4 > S_2M_1 > S_2M_3 > S_2M_2 > S_2M_4 > S_1M_1 > S_1M_3 > S_1M_2 > S_1M_4$$

At 195 DAS, significantly highest herbage yield per plant (96.21 g) was recorded with treatment combination S_3M_1 and the lowest herbage yield per plant (93.12 g) was recorded with treatment combination S_1M_4 .

The trend of various treatment combinations on herbage yield per plant at 195 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_3M_3 > S_2M_1 > S_2M_3 > S_3M_2 > S_3M_4 > S_2M_2 > S_2M_4 > S_1M_1 > S_1M_3 > S_1M_2 > S_1M_4$$

Significantly highest herbage yield per plant (110.14 g) was recorded with treatment combination S_3M_1 followed by S_2M_1 (110.02 g) at 225 DAS. The lowest herbage yield per plant (107.18 g) was recorded in treatment S_1M_4 .

Table: 9a **Effect of spacing and organic manure on herbage yield per plant (g/plant) of Indian spinach**
(45, 75, 105 and 135 DAS)

Treatme nt	Herbage yield per plant (g/plant)															
	45 DAS				75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	20.04	22.11	22.27	21.47	52.54	53.43	53.92	53.30	69.15	69.33	69.96	69.48	75.82	78.16	78.31	77.43
M₂	19.21	20.44	21.26	20.30	51.81	52.67	52.66	52.38	68.53	68.45	68.52	68.50	75.53	77.66	78.14	77.11
M₃	19.75	21.13	22.17	21.02	52.12	53.21	53.53	52.95	68.68	69.32	69.61	69.20	75.74	77.80	78.22	77.25
M₄	18.59	19.83	20.82	19.75	51.28	51.31	51.68	51.42	68.32	68.38	68.45	68.38	75.41	77.54	78.06	77.01
Mean	19.40	20.88	21.63		51.94	52.66	52.95		68.67	68.87	69.14		75.63	77.79	78.18	
	S	M	S × M		S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.002	0.003	0.008		0.007	0.009	0.027		0.002	0.002	0.007		0.0017	0.0022	0.007	
CD @ 5%	0.006	0.008	0.024		0.020	0.027	0.080		0.005	0.007	0.021		0.0049	0.0065	0.020	

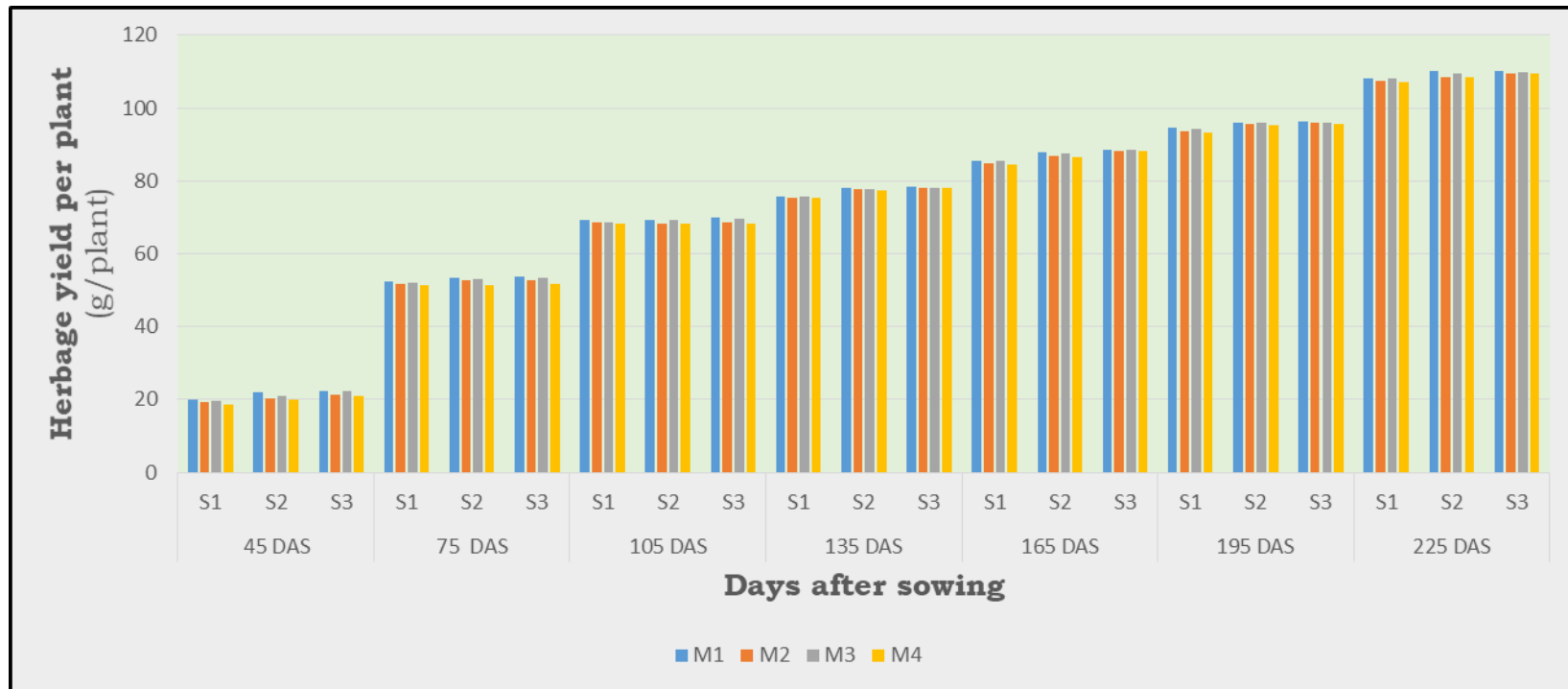
Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm S ₃ :- 50 × 60 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
	M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

Table: 9b **Effect of spacing and organic manure on herbage yield per plant (g/plant) of Indian spinach**
(165, 195 and 225 DAS)

Herbage yield per plant (g/plant)												
Treatment	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	85.56	87.79	88.57	87.30	94.54	96.02	96.21	95.59	108.31	110.02	110.14	109.49
M₂	84.75	86.88	88.31	86.65	93.66	95.72	95.84	95.07	107.34	108.65	109.49	108.50
M₃	85.39	87.64	88.46	87.16	94.23	95.88	96.03	95.38	108.12	109.53	109.88	109.17
M₄	84.46	86.64	88.19	86.43	93.12	95.37	95.74	94.74	107.18	108.33	109.34	108.28
Mean	85.04	87.24	88.38		93.89	95.75	95.95		107.74	109.13	109.71	
	S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.0014	0.0019	0.006		0.0016	0.0021	0.006		0.0016	0.002	0.007	
CD @ 5%	0.0041	0.0055	0.017		0.0046	0.0061	0.018		0.0048	0.006	0.019	

Treatment Details:		
Spacing	Organic manure	
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
S ₃ :- 50 × 60 cm	M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

Fig. 5 **Effect of spacing and organic manure on herbage yield per plant (g/plant) of Indian spinach (45, 75,105, 135, 165, 195 and 225 DAS)**



Treatment Details:		
Spacing	Organic manure	
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm, S ₃ :- 50 × 60 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
	M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

The trend of various treatment combinations on herbage yield per plant at 225 DAS in descending order was as follow,

$$\underline{S_3M_1} > S_2M_1 > S_3M_3 > S_2M_3 > S_3M_2 > S_3M_4 > S_2M_2 > S_2M_4 > S_1M_1 > \\ S_1M_3 > S_1M_2 > S_1M_4$$

The highest herbage yield per plant with respect to spacing and organic manure was recoded with S_3M_1 might be due to enough opportunity for the plant to receive maximum nutrient, aeration and sunlight as a result maximum photosynthesis could occur. For that maximum growth was attained and maximum foliage coverage with highest number and yield per plant of Indian spinach was found further, with respect to organic manure the highest herbage yield per plant reported with M_1 can be attributed to higher availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizers fulfilling the needs of plant throughout the cropping season.

4.2.2 **Herbage yield per plot (kg):**

4.2.2.1 **Effect of spacing (S):**

The data regarding effect of spacing on herbage yield per plot are given in Table 10a and 10b. It was observed from the data that herbage yield per plot affected significantly at 45, 75, 105, 135, 165, 195 and 225 days after sowing.

At 45 DAS, significantly highest herbage yield per plot (1.96 kg) was observed with treatment S_1 (50 × 30 cm) followed by S_2 (1.39 kg). The lowest herbage yield per plot (0.96 kg) was recorded in spacing S_3 (50 × 60 cm).

The trend of effect of spacing on herbage yield per plot (kg) at 45 DAS in descending order was as follows,

$$\underline{S_1} > S_2 > S_3$$

At 75 DAS, the highest herbage yield per plot (2.47 kg) was observed with treatment S_1 and it was found significantly superior. However, the lowest herbage yield per plot (1.22 kg) was observed in S_3 .

The trend of effect of spacing on herbage yield per plot (kg) at 75 DAS in descending order was as follows,

$$\underline{S_1} > S_2 > S_3$$

At 105 DAS, highest herbage yield per plot (3.04 kg) was recorded with treatment S_1 and it was found significantly superior over rest of all the spacing levels. However, the lowest herbage yield per plot (1.56 kg) was recorded in S_3 .

The trend of effect of spacing on herbage yield per plot (kg) at 105 DAS in descending order is as follows,

$$\underline{S_1} > S_2 > S_3$$

At 135 DAS, significantly highest herbage yield per plot (3.75 kg) was recorded with closer spacing 50×30 cm whereas, the lowest herbage yield per plot (1.86 kg) was recorded with wider spacing 50×60 cm.

The trend of effect of spacing on herbage yield per plot at 135 DAS in descending order was as follows,

$$\underline{S_1} > S_2 > S_3$$

At 165 DAS, significantly highest herbage yield per plot (4.15 kg) was found with treatment S_1 . However, the lowest herbage yield per plot (2.06 kg) found with treatment S_3 .

The trend of effect of spacing on herbage yield per plot at 165 DAS in descending order was as follows,

$$\underline{S_1} > S_2 > S_3$$

At 195 DAS, significantly highest herbage yield per plot (4.44 kg) was recorded with treatment S_1 while, the lowest herbage yield per plot (2.18 kg) was recorded in treatment S_3 .

The trend of effect of spacing on herbage yield per plot at 195 DAS in descending order was as follows,

$$S_1 > S_2 > S_3$$

At 225 DAS, the highest herbage yield per plot (5.14 kg) was recorded with treatment S_1 and it was found significantly superior. However, the lowest herbage yield per plot (2.60 kg) was recorded in S_3 .

The trend of effect of spacing on herbage yield per plot at 225 DAS in descending order was as follows,

$$\underline{S_1} > S_2 > S_3$$

The highest the herbage yield per plot was recorded in closer spacing S_1 and the lowest herbage yield per plot was observed in (S_3) wider spacing. The highest herbage yield per plot was recorded in closer spacing might be due to more plant population. Similar result were also reported by Seif and Ali (2003) in tomato, Mane *et al.* (2008) in spinach and Khale (2018) in amaranth.

4.2.8.2.1 **Effect of organic manure (M):**

The data regarding effect of organic manure on herbage yield per plot of Indian spinach are presented in (Table 10a and 10b). The herbage yield per plot of Indian spinach varied significantly among the different organic manure treatments at 45, 75, 105, 135, 165, 195 and 225 DAS.

At 45 DAS, significantly highest herbage yield per plot (1.57 kg) was recorded with treatment M_1 followed by M_3 (1.47

kg) and M₂ (1.42 kg). However, the lowest herbage yield per plot (1.28 kg) was recorded with treatment M₄.

The trend of effect of organic manure on herbage yield per plot at 45 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

At 75 DAS, significantly highest herbage yield per plot (2.00 kg) was recorded with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK. However, the lowest herbage yield per plot (1.63 kg) was recorded with application of neem cake @ 2 t/ha.

The trend of effect of organic manure on herbage yield per plot at 75 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 105 DAS, significantly highest herbage yield per plot (2.60 kg) was recorded with treatment M₁ followed by M₂ (2.37 kg) and the lowest herbage yield per plot (2.13 kg) was recorded with treatment M₄.

The trend of effect of organic manure on herbage yield per plot at 105 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 = M_4$$

At 135 DAS, significantly highest herbage yield per plot (2.99 kg) was recorded with treatment M₁ followed by M₃ (2.87 kg). However, the lowest herbage yield per plot (2.46 kg) was recorded with treatment M₄.

The trend of effect of organic manure on herbage yield per plot at 135 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

At 165 DAS, significantly highest herbage yield per plot (3.62 kg) was recorded with treatment M₁ whereas, the lowest herbage yield per plot (2.50 kg) was recorded with treatment M₄.

The trend of effect of organic manure on herbage yield per plot at 165 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

Similarly at 195 DAS, the highest herbage yield per plot (3.66 kg) was recorded with treatment M₁ followed by M₃ (3.42 kg) and the lowest herbage yield per plot (2.80 kg) was recorded with M₄.

The trend of effect of organic manure on herbage yield per plot at 195 DAS in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

At 225 DAS, the highest herbage yield per plot (4.32 kg) was observed with treatment M₁ and it was found significantly superior over rest of the treatment. However, the lowest herbage yield per plot (3.27 kg) was recorded in treatment M₄.

The trend of effect of organic manure on herbage yield per plot at 225 DAS in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

The highest herbage yield per plot was recorded in M₁ might be due to increase availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizers fulfilling the needs of plant throughout the cropping season.

The above findings have shown similarities with the result reported by Padmanabha *et al.* (2009) in palak, Umesha *et al.*

(2011) in brinjal, Premsekhar and Rajashree (2009) and Ola *et al.* (2018) in okra and Hashimi *et.al* (2019) in spinach.

4.2.2.3. **Interaction effect** ($S \times M$)

The interaction effect between spacing and organic manure on herbage yield per plot of Indian spinach was varied significantly at all growth stages (Table 10a and 10b).

At 45 DAS, significantly highest herbage yield per plot (2.10 kg) was recorded with treatment combination S_1M_1 followed by S_1M_3 (2.02 kg). The lowest herbage yield per plot (0.85 kg) was recorded with treatment S_3M_4 .

The trend of various treatment combinations on herbage yield per plot at 45 DAS in descending order was as follow,

$$S_1M_1 > S_1M_3 > S_1M_2 > S_1M_4 > S_2M_1 > S_2M_3 > S_2M_2 > S_2M_4 > S_3M_1 > \\ S_3M_3 = S_3M_2 > S_3M_4$$

At 75 DAS, significantly highest total herbage yield per plot (2.72 kg) was recorded with treatment combination S_1M_1 followed by S_1M_3 (2.53 kg), S_1M_2 (2.43 kg) and S_1M_4 (2.20 kg). The lowest total herbage yield per plot (1.07 kg) was found with treatment combination S_3M_4 .

The trend of various treatment combinations on herbage yield per plot at 75 DAS in descending order was as follow,

$$\underline{S_1M_1} > S_1M_3 > S_1M_2 > S_1M_4 > S_2M_1 > S_2M_3 > S_2M_2 > S_2M_4 > S_3M_1 > \\ S_3M_3 > S_3M_2 > S_3M_4$$

At 105 DAS, significantly highest herbage yield per plot (3.46 kg) was recorded with treatment combination S_1M_1 while,

S₃M₄ recorded the lowest herbage yield per plot (1.39 kg) which was at par with S₃M₂ (1.46).

The trend of various treatment combinations on herbage yield per plot at 105 DAS in descending order was as follow,

$$\underline{S_1M_1} > S_1M_3 > S_1M_2 > S_1M_4 > S_2M_1 > S_2M_3 > S_2M_4 > S_2M_2 > S_3M_1 > \\ S_3M_3 > \underline{S_3M_2} > \underline{S_3M_4}$$

At 135 DAS, significantly highest herbage yield per plot (4.10 kg) was recorded with treatment combination S₁M₁. However, the lowest herbage yield per plot (1.68 kg) was recorded with treatment combination S₃M₄

The trend of various treatment combinations on herbage yield per plot at 135 DAS in descending order was as follow,

$$\underline{S_1M_1} > S_1M_3 > S_1M_2 > S_1M_4 > S_2M_1 > S_2M_3 > S_2M_2 > S_2M_4 > S_3M_1 > \\ S_3M_3 > S_3M_2 > S_3M_4$$

At 165 DAS, significantly highest herbage yield per plot (5.34 kg) was recorded with treatment combination S₁M₁. The lowest herbage yield per plot (1.91 kg) was recorded in S₃M₄ which was at par with S₃M₂ (1.92 kg) S₃M₃ (2.15 kg) and S₃M₁ (2.26 kg).

The trend of various treatment combinations on herbage yield per plot at 165 DAS in descending order was as follow,

$$S_1M_1 > S_1M_3 > S_1M_2 > S_2M_1 > S_1M_4 > S_2M_3 > S_2M_2 > S_2M_4 > \underline{S_3M_1} > \\ \underline{S_3M_3} > \underline{S_3M_2} > \underline{S_3M_4}$$

Table: 10a **Effect of spacing and organic manure on herbage yield per plot (kg) of Indian spinach (45, 75,105 and 135 DAS)**

Herbage yield per plot (kg)																
Treatment	45 DAS				75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	2.10	1.53	1.07	1.57	2.72	1.94	1.34	2.00	3.46	2.57	1.76	2.60	4.10	2.89	1.99	2.99
M₂	1.95	1.34	0.95	1.42	2.43	1.74	1.20	1.79	2.75	2.20	1.46	2.13	3.62	2.62	1.81	2.68
M₃	2.02	1.43	0.95	1.47	2.53	1.84	1.25	1.87	3.17	2.34	1.61	2.37	3.93	2.75	1.95	2.87
M₄	1.76	1.24	0.85	1.28	2.20	1.63	1.07	1.63	2.77	2.22	1.39	2.13	3.36	2.33	1.68	2.46
Mean	1.96	1.39	0.96		2.47	1.79	1.22		3.04	2.33	1.56		3.75	2.65	1.86	
	S	M	S × M		S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.0010	0.0013	0.0039		0.0009	0.0011	0.0034		0.006	0.008	0.024		0.0011	0.0015	0.0045	
CD @ 5%	0.0029	0.0038	0.0115		0.0025	0.0034	0.0101		0.017	0.023	0.069		0.0033	0.0044	0.0133	

Treatment Details:		
Spacing		Organic manure
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm		M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK
S ₃ :- 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha
		M ₃ :- Poultry manure @ 4 t/ha
		M ₄ :- Neem cake @ 2 t/ha

Table: 10b **Effect of spacing and organic manure on herbage yield per plot (kg) of Indian spinach (165, 195 and 225 DAS)**

Herbage yield per plot (kg)												
Treatment	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	5.34	3.26	2.26	3.62	4.96	3.55	2.45	3.66	5.87	4.12	2.96	4.32
M₂	3.82	2.71	1.91	2.82	4.24	2.99	2.10	3.11	4.90	3.52	2.50	3.64
M₃	4.20	2.99	2.15	3.11	4.68	3.28	2.32	3.42	5.37	3.81	2.73	3.97
M₄	3.25	2.32	1.92	2.50	3.87	2.67	1.86	2.80	4.42	3.17	2.21	3.27
Mean	4.15	2.82	2.06		4.44	3.12	2.18		5.14	3.65	2.60	
	S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.032	0.042	0.13		0.007	0.003	0.009		0.0014	0.0019	0.006	
CD @ 5%	0.093	0.124	0.37		0.031	0.009	0.027		0.0041	0.0055	0.016	

Treatment Details:		
Spacing	Organic manure	
S ₁ :- 50 × 30 cm , S ₂ :- 50 × 45 cm S ₃ :- 50 × 60 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
	M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

At 195 DAS, significantly highest herbage yield per plot (4.96 kg) was recorded with treatment combination S_1M_1 followed by S_1M_3 (4.68 kg). However, the lowest herbage yield per plot (1.86 kg) was recorded in S_3M_4 .

The trend of various treatment combinations on herbage yield per plot at 195 DAS in descending order was as follow,

$$\underline{S_1M_1} > S_1M_3 > S_1M_2 > S_1M_4 > S_2M_1 > S_2M_3 > S_2M_2 > S_2M_4 > S_3M_1 > S_3M_3 > S_3M_2 > S_3M_4$$

At 225 DAS, significantly highest herbage yield per plot (5.87 kg) was recorded with treatment combination S_1M_1 followed by S_1M_3 (5.37 kg) and the lowest herbage yield per plot (2.21 kg) was recorded with treatment combination S_3M_4 .

The trend of various treatment combinations on herbage yield per plot at 225 DAS in descending order was as follow,

$$\underline{S_1M_1} > S_1M_3 > S_1M_2 > S_1M_4 > S_2M_1 > S_2M_3 > S_2M_2 > S_2M_4 > S_3M_1 > S_3M_3 > S_3M_2 > S_3M_4$$

The highest herbage yield per plot with respect to spacing and organic manure was recoded with treatment combination S_1M_1 might be due to higher plant population further, with respect to organic manure the highest herbage yield per plot reported with M_1 can be attributed to higher availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizers fulfilling the needs of plant throughout the cropping season.

4.2.3 **Total herbage yield per plant (g)**

The data pertaining to the total herbage yield per plant as influenced by different spacing, organic manure and their interactions are presented in Table 11.

4.2.3.1 Effect of spacing (S):

It was evident from data that total herbage yield per plant showed significant variation under different spacing. The highest total herbage yield per plant (406.23 g) was recorded with treatment S₃ followed by S₂ (403.18 g) whereas, the lowest herbage yield per plant (394.56 g) was recorded in S₁.

The trend of effect of spacing on herbage yield per plant in descending order was as follows,

$$S_3 > S_2 > S_1$$

Table: 11 **Effect of spacing and organic manure on total herbage yield per plant (g) of Indian spinach**

Treatment	Total herbage yield per plant (g/plant)			
	S ₁	S ₂	S ₃	Mean
M ₁	397.66	406.84	409.23	404.58
M ₂	393.50	401.82	404.72	400.01
M ₃	395.92	404.99	408.02	402.97
M ₄	391.18	399.08	402.94	397.73
Mean	394.56	403.18	406.23	
	S	M	S × M	
F test	Sig	Sig	Sig	
S.Em.±	0.009	0.012	0.035	
CD @ 5%	0.026	0.035	0.104	
Treatment Details:				
Spacing		Organic Manure		
S ₁ - 50 × 30 cm		M ₁ – FYM @ 10 t /ha + 100:50:50 kg/ha NPK		
S ₂ - 50 × 45 cm		M ₂ - Vermicompost @ 5 t/ha		
S ₃ - 50 × 60 cm		M ₃ - Poultry Manure @ 4 t/ha		
		M ₄ - Neem cake @ 2 t/ha		

The highest total herbage yield per plant with respect to spacing was recoded with treatment S₃ might be due to enough opportunity for the plant to receive maximum nutrient, aeration and sunlight as a result maximum photosynthesis could occur. For that maximum growth was attained and maximum foliage coverage with highest number and yield per plant of Indian

spinach was found. Similar results with respect to spacing obtained by Yoshizawa *et al.* (1981) in stem amaranth, Sharma *et al.* (2001) in lettuce and Mane *et al.* (2008) in spinach.

4.2.3.2. **Effect of organic manure (M):**

Total herbage yield per plant of Indian spinach varied significantly due to the application of different organic manure. The highest total herbage yield per plant (404.58 g) was recorded with treatment M₁ (FYM @ 10 t/ha + 100:50:50 kg/ha NPK) followed by M₃ (402.97 g). However, the lowest total herbage yield per plant (397.73 g) was recorded with treatment M₄ (neem cake @ 2 t/ha).

The trend of effect of organic manure on total herbage yield per plant in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

The highest total herbage yield per plant with respect organic manure was recoded in M₁ might be due to higher availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizers fulfilling the needs of plant throughout the cropping season. Similar results with respect to organic manure obtained by Premsekhar and Rajashree (2009) in okra, Padmanabha *et al.* (2009) in palak, Umesha *et al.* (2011) in brinjal, Ola *et al.* (2018) in okra, Hashimi *et.al* (2019) in spinach. This might be attributed to multifarious role of FYM and NPK in supply of nutrients as well as improvement in physical, chemical and biological environment of soil. Finally, it was reflected in better growth of plant with FYM.

4.2.3.3 **Interaction effect** (S × M)

The combined effect of plant spacing and organic manure in terms of total herbage yield per plant was found significant. The highest total herbage yield per plant (409.23 g) was recorded with treatment S₃M₁ followed by S₃M₃ (408.02 g) while, the lowest total herbage yield per plant (391.18 g) was found in S₁M₄.

The trend of various treatment combinations on total herbage yield per plant in descending order was as follow,

$$S_3M_1 > S_3M_3 > S_2M_1 > S_1M_3 > S_3M_2 > S_3M_4 > S_2M_2 > S_2M_4 > S_1M_1 > S_1M_3 > S_1M_2 > S_1M_4$$

The highest total herbage yield per plant was recoded with treatment S₃M₁ might be due to enough opportunity for the plant to receive maximum nutrient, aeration and sunlight as a result maximum photosynthesis could occur. For that maximum growth was attained and maximum foliage coverage with highest number and yield per plant of Indian spinach was found further, with respect to organic manure the highest herbage yield per plant reported with M₁ can be attributed to higher availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizers fulfilling the needs of plant throughout the cropping season.

4.2.4 **Total herbage yield per plot** (kg):

The data pertaining to the total herbage yield per plot (kg) as influenced by different spacing, organic manure and their interactions are presented in Table 12 and 12a.

4.2.4.1 **Effect of spacing (S):**

It was evident from data that total herbage yield per plot showed significant variation under different spacing. The highest total herbage yield per plot (24.95 kg) was observed under spacing S₁ (50 × 30 cm) and it was significantly superior over rest of the spacing levels. The lowest total herbage yield per plot (12.42 kg) was observed in S₃ (50 × 60 cm) spacing.

The trend of effect of spacing on total herbage yield per plot in descending order was as follows,

$$\underline{S_1} > S_2 > S_3$$

The highest total herbage yield per plot with respect to spacing was recorded in S₁ might be due to more plant population. Similar results with respect to spacing obtained by Yoshizawa *et al.* (1981) in stem amaranth, Sharma *et al.* (2001) in lettuce and Mane *et al.* (2008) in spinach.

4.2.4.2 **Effect of organic manure (M):**

Total herbage yield per plot of Indian spinach varied significantly due to the application of different organic manures. The highest total herbage yield per plot (20.75 kg) was recorded when the application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK) and it was found significantly superior over rest of the organic manure level. However, the lowest total herbage yield per plot (16.06 kg) was recorded with application of neem cake @ 2 t/ha.

The trend of effect of organic manure on total herbage yield per plot in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

The highest total herbage yield per plot with respect organic manure reported with M₁ due to higher availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizers fulfilling the

needs of plant throughout the cropping season. Similar results with respect to organic manure obtained by Premsekhar and Rajashree (2009) in okra and Padmanabha *et al.* (2009) in palak, Umesha *et al.* (2011) in brinjal, Ola *et al.* (2018) in okra and Hashimi *et.al* (2019) in spinach.

Table: 12 **Effect of spacing and organic manure on total herbage yield per plot (kg) of Indian spinach**

Treatment	Total herbage yield per plot (kg)			
	S ₁	S ₂	S ₃	Mean
M ₁	28.55	19.86	13.83	20.75
M ₂	23.71	17.12	11.93	17.59
M ₃	25.89	18.43	12.96	19.10
M ₄	21.64	15.57	10.98	16.06
Mean	24.95	17.75	12.42	
	S	M	S × M	
F test	Sig	Sig	Sig	
S.Em.±	0.032	0.042	0.13	
CD @ 5%	0.093	0.124	0.37	
Treatment Details:				
Spacing S ₁ - 50 × 30 cm S ₂ - 50 × 45 cm S ₃ - 50 × 60 cm	Organic Manure M ₁ :- FYM @ 10 t /ha + 100:50:50 kg/ha NPK M ₂ - Vermicompost @ 5 t/ha M ₃ - Poultry Manure @ 4 t/ha M ₄ - Neem cake @ 2 t/ha			

4.2.7.3.1. **Interaction effect (S × M):**

The combined effect of spacing and organic manure on total herbage yield per plot. Significantly highest total herbage yield per plot (28.55 kg) was recorded with treatment combination S₁M₁ and it was found significantly superior. While, the lowest total herbage yield per plot (10.98 kg) was found with treatment combination S₃M₄.

The trend of various treatment combinations on total herbage yield per plot in descending order was as follow,

$$\underline{S_1M_1} > S_1M_3 > S_1M_2 > S_1M_4 > S_2M_1 > S_2M_3 > S_2M_2 > S_2M_4 > S_3M_1 > \\ S_3M_3 > S_3M_2 > S_3M_4$$

The highest total herbage yield per plot was recoded in S_1M_1 might be due to higher plant population further, with respect to organic manure the total highest herbage yield per plot reported with M_1 can be attributed to higher availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizers fulfilling the needs of plant throughout the cropping season.

4.2.5 **Total herbage yield per hectare (t)**

The data pertaining to the total herbage yield per hectare (t/ha) as influenced by different spacing, organic manure and their interactions are presented in Table 13 and depicted in Fig 6.

4.2.5.1 **Effect of spacing (S):**

The critical perusal of data presented in Table 13 the total herbage yield per hectare showed significant variation with respect to spacing. The highest total herbage yield per hectare (27.72 t) was found in S_1 (50 × 30 cm) and it was found significantly superior. The lowest total herbage yield per hectare (13.81 t) was recorded in S_3 (50 × 60 cm).

The trend of effect of spacing on total herbage yield per hectare in descending order was as follows,

$$\underline{S_1} > S_2 > S_3$$

The highest total herbage yield per hectare with respect to spacing was recoded in S_1 might be due to more plant population.

Similar results with respect to spacing obtained by Seif and

Ali (2003) in tomato, Mane *et al.* (2008) in spinach and Khale (2018) in amaranth.

Table: 13 **Effect of spacing and organic manure on total herbage yield per hectare (t) on Indian spinach**

Treatment	Total herbage yield per hectare (t)			
	S ₁	S ₂	S ₃	Mean
M₁	31.72	22.07	15.36	23.05
M₂	26.34	19.02	13.26	19.54
M₃	28.77	20.48	14.40	21.22
M₄	24.04	17.30	12.20	17.85
Mean	27.72	19.72	13.81	
	S	M	S × M	
F test	Sig	Sig	Sig	
S.Em.±	0.035	0.047	0.141	
CD @ 5%	0.103	0.137	0.412	
Treatment Details:				
Spacing S ₁ - 50 × 30 cm S ₂ - 50 × 45 cm S ₃ - 50 × 60 cm	Organic Manure M ₁ – FYM @ 10 t /ha + 100:50:50 kg/ha NPK M ₂ - Vermicompost @ 5 t/ha M ₃ - Poultry Manure @ 4 t/ha M ₄ - Neem cake @ 2 t/ha			

4.2.5.2 **Effect of organic manure (M):**

Among the different organic manure tried under present investigation there was significant effect on total herbage yield per hectare of Indian spinach. The highest total herbage yield per hectare (23.05 t) was recorded with treatment M₁ and it was found significantly superior over rest of the organic manure levels. However, the lowest total herbage yield per hectare (17.85 t) was found in M₄.

The trend of effect of organic manure on total herbage yield per plot in descending order was as follows,

$$\underline{M_1} > M_3 > M_2 > M_4$$

The highest total herbage yield per hectare was recoded with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK might be due to higher availability of nitrogen, phosphorus and

potassium to the plants initially through inorganic fertilizers along with FYM fulfilling the needs of plant throughout the cropping season.

Similar results with respect to organic manure obtained by Premsekhar and Rajashree (2009) in okra, Padmanabha *et al.* (2009) in palak, Umesha *et al.* (2011) in brinjal, Ola *et al.* (2018) in okra and Hashimi *et.al* (2019) in spinach. This might be attributed to multifarious role of FYM and NPK in supply of nutrients as well as improvement in physical, chemical and biological environment of soil. Finally, it was reflected in better growth of plant with FYM.

4.2.5.3 **Interaction effect** (S × M):

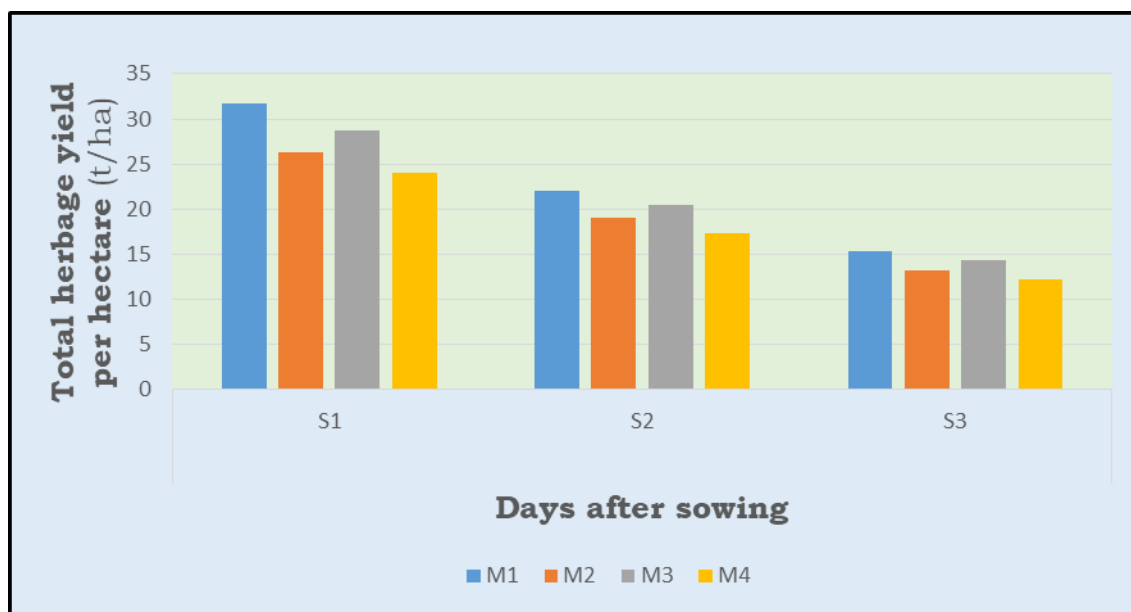
The data presented in Table 13 showed the different spacing and organic manure had significant effect on total herbage yield per hectare. The highest total herbage yield per hectare (31.72 t) was recorded with treatment combination S₁M₁ and it was found significantly superior over all treatment while, S₃M₄ recorded the lowest total herbage yield per hectare (12.20 t).

The trend of various treatment combinations on total herbage yield per hectare in descending order was as follow,

$$\underline{S_1M_1} > S_1M_3 > S_1M_2 > S_1M_4 > S_2M_1 > S_2M_3 > S_2M_2 > S_2M_4 > S_3M_1 > \\ S_3M_3 > S_3M_2 > S_3M_4$$

The highest total herbage yield per hectare was recoded in S₁M₁ might be due to higher plant population further, with respect to organic manure the highest total herbage yield per hectare reported with M₁ can be attributed to higher availability of nitrogen, phosphorus and potassium to the plants initially through FYM as well through inorganic fertilizers fulfilling the needs of plant throughout the cropping season.

Fig. 6 **Effect of spacing and organic manure on herbage yield per hectare (t/ha) of Indian spinach**



Treatment Details:	
Spacing	Organic Manure
S ₁ - 50 × 30 cm	M ₁ – FYM @ 10 t /ha + 100:50:50 kg/ha NPK
S ₂ - 50 × 45 cm	M ₂ - Vermicompost @ 5 t/ha
S ₃ - 50 × 60 cm	M ₃ - Poultry Manure @ 4 t/ha
	M ₄ - Neem cake @ 2 t/ha

4.3. **Quality parameters**

Eating leafy vegetables provides health benefits. They provide vitamin, minerals and nutrients vital for health and maintenance of our body. Especially, the leafy vegetables are important source of nutrients including calcium, iron, dietary fibre, folic acid, vitamin A and vitamin C. Coincidentally, Indian spinach is rich source of Vitamin A and Vitamin C.

4.3.1 **Absolute growth rate** (cm/day)

4.3.1.1 **Effect of spacing** (S):

At 75 DAS, the data presented in Table 14a revealed that the highest AGR (0.52 cm/day) was observed with treatment S₃. However, the lowest AGR (0.10 cm/day) was recorded with treatment S₁.

At 105 DAS, the data revealed that the highest AGR (0.09 cm/day) was observed with treatment S₃. However, the lowest AGR (0.07 cm/day) was recorded with treatment S₁.

At 135 DAS, the critical perusal of data revealed that the highest AGR (0.19 cm/day) was observed with treatment S₁. However, the lowest AGR (0.10 cm/day) was recorded with treatment S₃.

At 165 DAS, the data presented in Table 14b revealed that the highest AGR (0.22 cm/day) was observed with treatment S₃. However, the lowest AGR (0.09 cm/day) was recorded with treatment S₁.

At 195 DAS, the data revealed that the highest AGR (0.35 cm/day) was observed with treatment S₃. However, the lowest AGR (0.32 cm/day) was recorded with treatment S₂.

At 225 DAS, the data presented in Table 14b revealed that the highest AGR (0.21 cm/day) was observed with treatment S₁. However, the lowest AGR (0.06 cm/day) was recorded with treatment S₃.

4.3.1.2 **Effect of organic manure (M):**

At 75 DAS, the highest AGR (0.35 cm/day) was recorded with treatment M₄. While, the lowest AGR (0.29 cm/day) was recorded with treatment M₁.

At 105 DAS, the highest AGR (0.13 cm/day) was recorded with treatment M₁ and M₃. While, the lowest AGR (0.03 cm/day) was recorded with treatment M₄ and M₂.

At 135 DAS, the highest AGR (0.17 cm/day) was recorded with treatment M₁. While, the lowest AGR (0.07 cm/day) was recorded with treatment M₄.

At 165 DAS, the highest AGR (0.22 cm/day) was recorded with treatment M₁. While, the lowest AGR (0.12 cm/day) was recorded with treatment M₄.

At 195 DAS, the highest AGR (0.37 cm/day) was recorded with treatment M₂. While, the lowest AGR (0.31 cm/day) was recorded with treatment M₃ and M₁.

At 225 DAS, the highest AGR (0.22 cm/day) was recorded with treatment M₄. While, the lowest AGR (0.05 cm/day) was recorded with treatment M₁.

4.3.1.3 **Interaction effect (S × M):**

At 75 DAS, highest AGR (0.54 cm/day) was recorded with treatment combination S₃M₁. However, the lowest AGR (0.07 cm/day) was recorded with treatment combination S₁M₄.

Table: 14a **Effect of spacing and organic manure on absolute growth rate (cm/day) of Indian spinach** (75, 105 and 135 DAS)

Treatment	Absolute growth rate (cm/day)											
	75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	0.07	0.30	0.50	0.29	0.17	0.11	0.09	0.13	0.18	0.18	0.15	0.17
M₂	0.12	0.39	0.51	0.34	0.01	0.01	0.08	0.03	0.24	0.10	0.05	0.13
M₃	0.07	0.39	0.52	0.33	0.17	0.12	0.10	0.13	0.18	0.15	0.15	0.16
M₄	0.14	0.35	0.54	0.35	0.01	0.05	0.04	0.03	0.16	0.01	0.05	0.07
Mean	0.10	0.36	0.52		0.09	0.07	0.08		0.19	0.11	0.10	

Treatment Details:			
Spacing		Organic manure	
S ₁ - 50 × 30 cm,	S ₂ - 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
S ₃ - 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

Table: 14b **Effect of spacing and organic manure on absolute growth rate (cm/day) of Indian spinach** (165, 195 and 225 DAS)

Treatment	Absolute growth rate (cm/day)											
	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	0.11	0.26	0.26	0.22	0.40	0.25	0.29	0.31	0.07	0.02	0.07	0.05
M₂	0.07	0.14	0.24	0.15	0.28	0.43	0.40	0.37	0.32	0.08	0.04	0.15
M₃	0.08	0.22	0.26	0.19	0.36	0.29	0.29	0.31	0.16	0.01	0.05	0.07
M₄	0.10	0.12	0.14	0.12	0.31	0.31	0.44	0.35	0.30	0.27	0.08	0.22
Mean	0.09	0.19	0.22		0.34	0.32	0.35		0.21	0.09	0.06	

Treatment Details:			
Spacing		Organic manure	
S ₁ - 50 × 30 cm,	S ₂ - 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
S ₃ - 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

At 105 DAS, the highest AGR (0.17 cm/day) was recorded with treatment combination S₃M₁. However, the lowest AGR (0.01 cm/day) was recorded with treatment combination S₂M₂.

At 135 DAS, highest AGR (0.24 cm/day) was recorded with treatment combination S₃M₁. However, the lowest AGR (0.01 cm/day) was recorded with treatment combination S₁M₄.

At 165 DAS, the highest AGR (0.26 cm/day) was recorded with treatment combination S₃M₁. However, the lowest AGR (0.07 cm/day) was recorded with treatment combination S₁M₄.

At 195 DAS, the highest AGR (0.44 cm/day) was recorded with treatment combination S₃M₁. However, the lowest AGR (0.25 cm/day) was recorded with treatment combination S₁M₄.

At 225 DAS, highest AGR (0.32 cm/day) was recorded with treatment combination S₃M₁. However, the lowest AGR (0.01 cm/day) was recorded with treatment combination S₁M₄.

4.3.2 **Relative growth rate** (cm/cm/day)

4.3.2.1 **Effect of spacing** (S):

At 75 DAS, the highest RGR (0.0220 cm/cm/day) was observed with treatment S₃. While, the lowest RGR (0.0044 cm/cm/day) was recorded with treatment S₁.

At 105 DAS, the data revealed that the highest RGR (0.003 cm/cm/day) was observed with treatment S₁. While, the lowest RGR (0.002 cm/cm/day) was recorded with treatment S₃.

At 135 DAS, the highest RGR (0.0066 cm/cm/day) was observed with treatment S₁. While, the lowest RGR (0.0029 cm/cm/day) was recorded with treatment S₃.

At 165 DAS, the data revealed that the highest RGR (0.0059 cm/cm/day) was observed with treatment S₃. While, the lowest RGR (0.0028 cm/cm/day) was recorded with treatment S₁.

At 195 DAS, the critical perusal of data presented in Table 15b revealed that the highest RGR (0.0089 cm/cm/day) was observed with treatment S₁. While, the lowest RGR (0.0078 cm/cm/day) was recorded with treatment S₂.

At 225 DAS, the data regarding RGR revealed that the highest RGR (0.00487 cm/cm/day) was observed with treatment S₁. While, the lowest RGR (0.00121 cm/cm/day) was recorded with treatment S₃.

4.3.2.2 **Effect of organic manure (M):**

At 75 DAS, the highest RGR (0.0153 cm/cm/day) was recorded with treatment M₄ whereas, the lowest RGR (0.0116 cm/cm/day) was recorded with treatment M₁.

At 105 DAS, the highest RGR (0.004 cm/cm/day) was recorded with treatment M₁ whereas, the lowest RGR (0.001 cm/cm/day) was recorded with treatment M₄.

At 135 DAS, the highest RGR (0.0051 cm/cm/day) was recorded with treatment M₁ whereas, the lowest RGR (0.0026 cm/cm/day) was recorded with treatment M₄.

At 165 DAS, the highest RGR (0.0055 cm/cm/day) was recorded with treatment M₁ whereas, the lowest RGR (0.0039 cm/cm/day) was recorded with treatment M₄.

Table: 15a **Effect of spacing and organic manure on relative growth rate (cm/ cm/day) of Indian spinach** (75, 105 and 135 DAS)

Relative growth rate (cm/ cm/day)												
Treatment	75 DAS				105 DAS				135 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	0.0030	0.0119	0.0199	0.0116	0.006	0.004	0.003	0.004	0.0057	0.0054	0.0043	0.0051
M₂	0.0053	0.0165	0.0229	0.0149	0.000	0.000	0.003	0.001	0.0088	0.0033	0.0014	0.0045
M₃	0.0028	0.0162	0.0214	0.0135	0.006	0.004	0.003	0.004	0.0057	0.0045	0.0042	0.0048
M₄	0.0064	0.0156	0.0240	0.0153	0.000	0.002	0.001	0.001	0.0062	0.0001	0.0015	0.0026
Mean	0.0044	0.0151	0.0220		0.003	0.002	0.002		0.0066	0.0033	0.0029	

Treatment Details:			
Spacing		Organic manure	
S ₁ - 50 × 30 cm,	S ₂ - 50 × 45 cm	M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK	M ₃ :- Poultry manure @ 4 t/ha
S ₃ - 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha	M ₄ :- Neem cake @ 2 t/ha

Table: 15b **Effect of spacing and organic manure on relative growth rate (cm/ cm/day) of Indian spinach** (165, 195 and 225 DAS)

Relative growth rate (cm/ cm/day)												
Treatment	165 DAS				195 DAS				225 DAS			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	0.0033	0.0068	0.0063	0.0055	0.0097	0.0053	0.0060	0.0070	0.00140	0.00049	0.00128	0.00106
M₂	0.0023	0.0042	0.0068	0.0044	0.0079	0.0107	0.0092	0.0093	0.00747	0.00168	0.00082	0.00332
M₃	0.0023	0.0057	0.0063	0.0048	0.0090	0.0064	0.0060	0.0071	0.00347	0.00007	0.00103	0.00152
M₄	0.0034	0.0041	0.0041	0.0039	0.0089	0.0087	0.0109	0.0095	0.00714	0.00623	0.00173	0.00503
Mean	0.0028	0.0052	0.0059		0.0089	0.0078	0.0080		0.00487	0.00212	0.00121	

Treatment Details:		
Spacing		Organic manure
S ₁ - 50 × 30 cm, S ₂ - 50 × 45 cm		M ₁ :- FYM @ 10 t/ha + 100:50:50 kg/ha NPK
S ₃ - 50 × 60 cm		M ₂ :- Vermicompost @ 5 t/ha
		M ₃ :- Poultry manure @ 4 t/ha
		M ₄ :- Neem cake @ 2 t/ha

At 195 DAS, the highest RGR (0.0095 cm/cm/day) was recorded with treatment M₄ whereas, the lowest RGR (0.0070 cm/cm/day) was recorded with treatment M₁.

At 225 DAS, the highest RGR (0.00503 cm/cm/day) was recorded with treatment M₄ whereas, the lowest RGR (0.00106 cm/cm/day) was recorded with treatment M₁.

4.3.2.3 **Interaction effect** (S × M):

At 75 DAS, the highest RGR (0.0240 cm/cm/day) was recorded with treatment combination S₃M₄. While, the lowest RGR (0.0028 cm/cm/day) was recorded with treatment combination S₁M₃.

At 105 DAS, the highest RGR (0.006 cm/cm/day) was recorded with treatment combination S₁M₁. While, the lowest RGR (0.000 cm/cm/day) was recorded with treatment combination S₁M₄.

At 135 DAS, the highest RGR (0.0088 cm/cm/day) was recorded with treatment combination S₁M₂. While, the lowest RGR (0.0001 cm/cm/day) was recorded with treatment combination S₂M₄.

At 165 DAS, the highest RGR (0.0068 cm/cm/day) was recorded with treatment combination S₂M₁. While, the lowest RGR (0.0023 cm/cm/day) was recorded with treatment combination S₁M₂.

At 195 DAS, the highest RGR (0.0109 cm/cm/day) was recorded with treatment combination S₃M₄. While, the lowest RGR

(0.0053 cm/cm/day) was recorded with treatment combination S₂M₁.

At 225 DAS, the highest RGR (0.00747 cm/cm/day) was recorded with treatment combination S₁M₂. While, the lowest RGR (0.00007 cm/cm/day) was recorded with treatment combination S₂M₃.

4.3.3 **Vitamin A content** (mg/100 g)

β- Carotene is precursor of vitamin A and is important quality parameter in Indian spinach. The data pertaining to β- carotene content are presented in Table 16.

4.3.3.1 **Effect of spacing (S):**

The effect of spacing on the vitamin A present in Indian spinach showed non-significant variation. The range of vitamin A varied from 3.54 mg to 3.69 mg.

The trend of effect of effect of spacing on vitamin A content in descending order was as follows,

$$S_3 > S_2 > S_1$$

4.3.3.2 **Effect of organic manure (M):**

The data regarding the vitamin A showed significant variation with respect to different organic manure. The highest vitamin A (3.71 mg/100 g) was found with treatment M₁ which was at par with M₃ (3.69 mg/100 gm) and M₄ (3.65 mg/100gm). However, the lowest vitamin A (3.35 mg/100 g) was recorded with treatment M₂.

The trend of effect of spacing on vitamin A content in descending order was as follows,

$$M_1 > M_3 > M_4 > M_2$$

Table: 16. **Effect of spacing and organic manure on vitamin A**
(mg/100 g) **content of Indian spinach**

Treatment	Vitamin A (mg/100 g)			
	S ₁	S ₂	S ₃	Mean
M ₁	3.68	3.71	3.73	3.71
M ₂	3.16	3.22	3.66	3.35
M ₃	3.66	3.69	3.71	3.69
M ₄	3.65	3.66	3.65	3.65
Mean	3.54	3.57	3.69	
	S	M	S × M	
F test	NS	Sig	NS	
S.Em.±	0.02	0.03	0.09	
CD @ 5%	--	0.09	--	
Treatment Details:				
Spacing S ₁ - 50 × 30 cm S ₂ - 50 × 45 cm S ₃ - 50 × 60 cm		Organic Manure M ₁ - FYM @ 10 t/ha + 100:50:50 kg/ha NPK M ₂ - Vermicompost @ 5 t/ha M ₃ - Poultry Manure @ 4 t/ha M ₄ - Neem cake @ 2 t/ha		

4.3.3.3. Interaction effect (S × M):

It was evident from data the vitamin A content in Indian spinach showed non-significant variation with respect to interaction between spacing and organic manure. The vitamin content varied from 3.16 mg to 3.73 mg/100 g.

The trend of interaction effect on vitamin A content in descending order was as follows,

$$S_3M_1 > S_3M_3 > S_2M_1 > S_2M_3 > S_1M_1 > S_3M_2 = S_2M_4 = S_1M_3 > S_3M_4 = \\ S_1M_4 > S_2M_2 > S_1M_2$$

4.3.4. Ascorbic acid content (mg/100g)

The data pertaining to variation in ascorbic content of Indian

spinach as affected by different spacing, organic manure and their interactions are showed in Table 17.

Table: 17. **Effect of spacing and organic manure on ascorbic acid (mg/100gm) content of Indian spinach**

Treatment	Ascorbic acid (mg/100gm)			
	S ₁	S ₂	S ₃	Mean
M ₁	67.31	67.30	67.35	67.32
M ₂	62.79	62.82	63.17	62.93
M ₃	68.64	68.66	68.71	68.67
M ₄	66.61	66.64	66.64	66.63
Mean	66.34	66.36	66.47	
	S	M	S × M	
F test	NS	Sig	NS	
S.Em.±	0.01	0.02	0.05	
CD @ 5%	--	0.06	--	
Treatment Details:				
Spacing S ₁ - 50 × 30 cm S ₂ - 50 × 45 cm S ₃ - 50 × 60 cm		Organic Manure M ₁ - FYM @ 10 t/ha + 100:50:50 kg/ha NPK M ₂ - Vermicompost @ 5 t/ha M ₃ - Poultry Manure @ 4 t/ha M ₄ - Neem cake @ 2 t/ha		

4.3.4.1 Effect of spacing (S):

The data presented in Table 17 showed that ascorbic acid content of Indian spinach had non-significant variation with respect to spacing. The ascorbic acid varied from 66.34 mg to 66.47 mg.

The trend of effect of effect of spacing on ascorbic acid content in descending order was as follows,

$$S_3 > S_2 > S_1$$

Effect of spacing does not showed any significant effect on ascorbic acid content. Similar, results were reported by Spaldon (1968) in spinach and Seif and Ali (2003) in tomato.

4.3.4.2. **Effect of organic manure (M):**

The data related to ascorbic acid content of Indian spinach was significantly affected by different organic manure is presented in Table 17. The highest ascorbic acid (68.67 mg/100g) was recorded with treatment M₃. However, the lowest ascorbic acid (62.93 mg/100g) was recorded with treatment M₂.

The trend of effect of spacing on ascorbic acid content in descending order was as follows,

$$\underline{M_3} > M_1 > M_4 > M_2$$

4.3.4.3. **Interaction effect (S × M):**

The interaction effect between spacing and organic manure on ascorbic acid content of Indian spinach was found non-significant. The ascorbic acid content in Indian spinach varied from 62.79 mg to 68.71 mg.

The trend of interaction effect on ascorbic acid content in descending order was as follows,

$$S_3M_3 > S_2M_3 > S_1M_3 > S_3M_1 > S_1M_1 > S_2M_1 > S_3M_4 = S_2M_4 > S_1M_4 > \\ S_3M_2 > S_2M_2 > S_1M_2$$

4.3.5 **Dry matter (%)**

The data on effect of spacing, organic manure and their interaction on dry matter content is presented in Table 18.

4.3.5.1 **Effect of spacing (S):**

The data regarding the dry matter content showed significant variation with respect to spacing. The highest dry matter (14.81 %) was recorded with treatment S₃.

was recorded with treatment S₃ and it was significantly superior over rest of spacing. Whereas, the lowest dry matter (11.77 %) was recorded with treatment S₁.

The trend of effect of spacing on dry matter of Indian spinach in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

It might be due to the reason that in wider spacing plant receives enough light and nutrients which leads to maximum assimilation of nutrients that leads to attain highest dry matter content of plant. Similar results were found by Waseem and Nadeem (2001) in spinach, Sharma *et al.* (2001) in lettuce, Majumder (2007), Pawar (2017) and Khale (2018) in amaranth.

Table: 18. **Effect of spacing and organic manure on dry matter (%) content of Indian spinach**

Treatment	Dry matter (%)			
	S ₁	S ₂	S ₃	Mean
M ₁	13.89	14.34	16.42	14.88
M ₂	11.52	13.42	14.19	13.04
M ₃	12.32	13.65	15.83	13.93
M ₄	9.36	11.67	12.81	11.28
Mean	11.77	13.27	14.81	
	S	M	S × M	
F test	Sig	Sig	Sig	
S.Em.±	0.0006	0.0008	0.002	
CD @ 5%	0.0018	0.0024	0.007	
Treatment Details:				
Spacing S ₁ - 50 × 30 cm S ₂ - 50 × 45 cm S ₃ - 50 × 60 cm	Organic Manure M ₁ - FYM @ 10 t/ha + 100:50:50 kg/ha NPK M ₂ - Vermicompost @ 5 t/ha M ₃ - Poultry Manure @ 4 t/ha M ₄ - Neem cake @ 2 t/ha			

4.3.5.2. **Effect of organic manure (M):**

It is evident from data presented in Table 18 that different organic manure had significant effect on dry matter content of Indian spinach. The highest dry matter (14.88 %) was recorded with treatment M₁. However, the lowest dry matter (11.28 %) was recorded with treatment M₄.

The trend of effect of organic manure on dry matter (%) in descending order was as follows,

$$M_1 > M_3 > M_2 > M_4$$

During present investigation it was observed that the organic manure had a significant effect on the dry matter content of Indian spinach. The highest dry matter content was recorded with treatment M₁, while, the lowest dry matter was recorded with treatment M₄. Similar results were found by Padmanabha *et al.* (2009) in palak, Kushare *et al.* (2010) and Gunjal (2010) in grain amaranth.

4.3.5.3. **Interaction effect (S × M):**

Various treatment combinations under study recorded that significant differences in dry matter content of Indian spinach. Among the various treatment combinations the highest dry matter (16.42 %) was recorded with treatment combination S₃M₁ while, S₁M₄ recorded the lowest dry matter (9.36 %).

The trend of effect of various treatment combinations on dry matter in descending order was as follow,

$$S_3M_1 > S_3M_2 > S_2M_1 > S_3M_2 > S_1M_1 > S_2M_3 > S_2M_2 > S_3M_4 > S_1M_3 > \\ S_2M_4 > S_1M_2 > S_1M_4$$

It might be due to favorable combination effect of spacing and organic manure on dry matter content of Indian spinach.

Fig. 7 **Effect of spacing and organic manure on dry matter content (%) of Indian spinach**

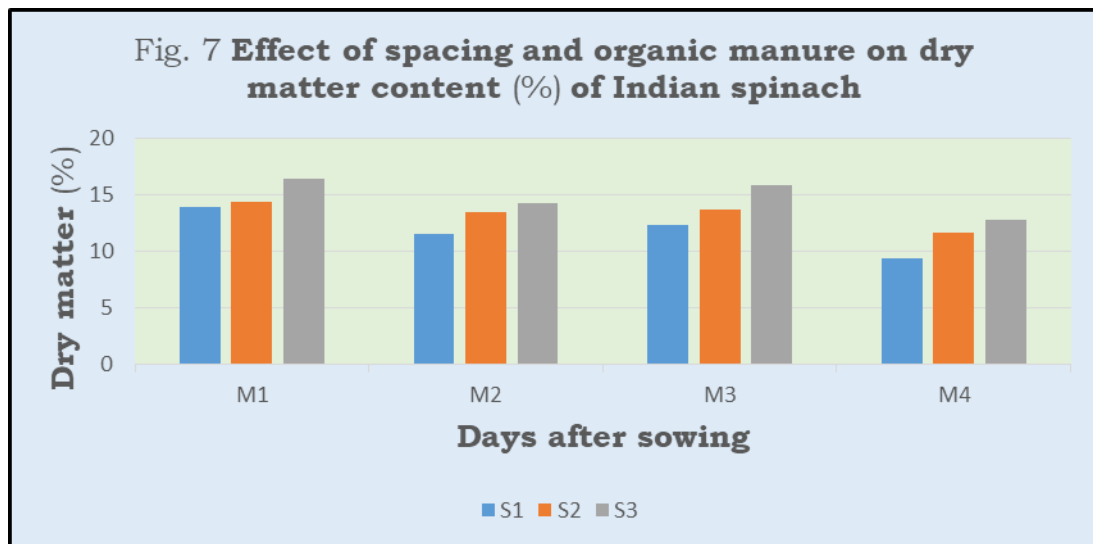
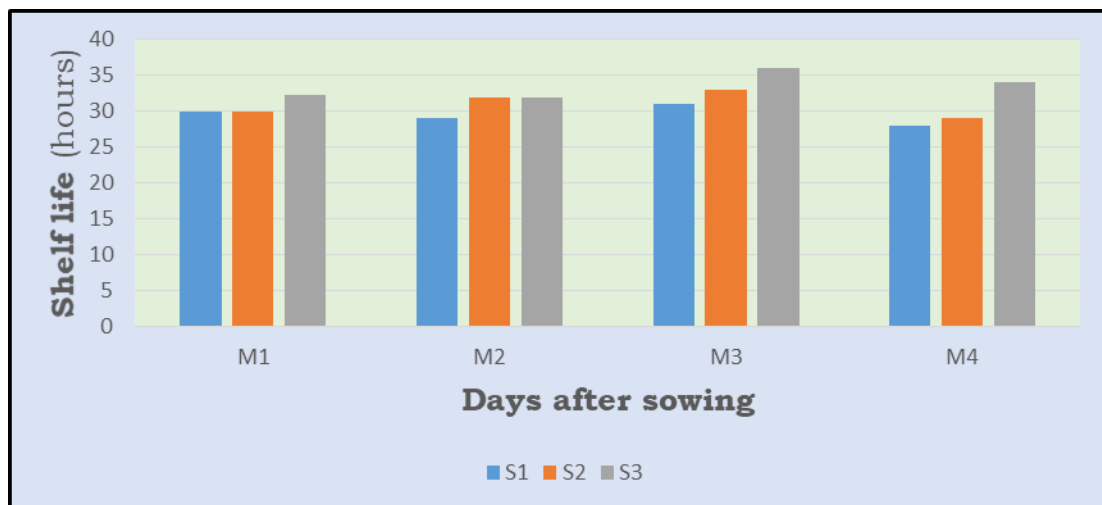


Fig. 8 **Effect of spacing and organic manure on shelf life (hours) of Indian spinach**



Treatment Details:

Spacing

S₁ - 50 × 30 cm

S₂ - 50 × 45 cm

S₃ - 50 × 60 cm

Organic Manure

M₁ - FYM @ 10 t /ha + 100:50:50 kg/ha NPK

M₂ - Vermicompost @ 5 t/ha

M₃ - Poultry Manure @ 4 t/ha

M₄ - Neem cake @ 2 t/ha

4.3.6 Shelf life (hrs.)

The data on effect of spacing, organic manure and their interaction on shelf life is presented in Table 19.

Table: 19. **Effect of spacing and organic manure on shelf life (hrs.) of Indian spinach**

Treatment	Shelf life (hrs.)			
	S ₁	S ₂	S ₃	Mean
M ₁	30.00	30.00	32.33	30.78
M ₂	29.00	32.00	32.00	31.00
M ₃	31.00	33.00	36.00	33.33
M ₄	28.00	29.00	34.00	30.33
Mean	29.50	31.00	33.58	
	S	M	S × M	
F test	Sig	Sig	Sig	
S.Em.±	0.03	0.04	0.11	
CD @ 5%	0.08	0.11	0.33	
Treatment Details:				
Spacing S ₁ - 50 × 30 cm S ₂ - 50 × 45 cm S ₃ - 50 × 60 cm	Organic Manure M ₁ - FYM @ 10 t/ha + 100:50:50 kg/ha NPK M ₂ - Vermicompost @ 5 t/ha M ₃ - Poultry Manure @ 4 t/ha M ₄ - Neem cake @ 2 t/ha			

4.3.6.1 Effect of spacing (S):

The data regarding the shelf life content showed significant variation with respect to spacing. The highest shelf life (33.58 hours) was recorded with treatment S₃ and it was significantly superior over rest of spacing. Whereas, the lowest shelf life (29.50 hours) was recorded with treatment S₁.

The trend of effect of spacing on shelf life of Indian spinach in descending order was as follows,

$$\underline{S_3} > S_2 > S_1$$

4.3.6.2. **Effect of organic manure (M):**

It is evident from data presented in Table 19 that different organic manure had significant effect on shelf life content of Indian spinach. The highest shelf life (33.33 hours) was recorded with treatment M₃. However, the lowest shelf life (30.33 hours) was recorded with treatment M₄.

The trend of effect of organic manure on shelf life (%) in descending order was as follows,

$$M_3 > M_2 > M_1 > M_4$$

4.3.6.3. **Interaction effect (S × M):**

Various treatment combinations under study had significant differences in shelf life of Indian spinach. Among the various treatment combinations the highest shelf life (36.00 hours) was recorded with treatment combination S₃M₃ while, S₁M₄ recorded the lowest shelf life (28.00 hours).

The trend of effect of various treatment combinations on shelf life in descending order was as follow,

$$S_3M_3 > S_3M_4 > S_2M_3 > S_3M_1 > S_3M_2 = S_2M_2 > S_1M_3 > S_2M_1 = S_1M_1 > S_2M_4 > S_1M_2 > S_1M_4$$

It might be due to favorable combination effect of spacing and organic manure on shelf life of Indian spinach.

4.4 **Soil analysis (After harvesting)**

4.4.1 **pH**

Soil pH is important because it affects the availability of nutrients to plants. Acidic soil has a pH below 7 whereas the alkaline soil has a pH above 7.

The data related to effect of spacing, organic manure and their interactions showed significant effect on soil pH are presented in Table 20.

4.4.1.1 Effect of spacing (S):

The data in respect of pH of soil was significantly influenced due to different spacing. The highest pH (5.64) was recorded with spacing 50 × 60 cm *i.e.* (S₃). However, the lowest pH (5.47) was recorded with spacing 50 × 30 cm *i.e.* (S₁).

The trend of effect of spacing on pH of soil in descending order is as follows,

$$S_3 > S_2 > S_1$$

Table: 20. **Effect of spacing and organic manure on soil after harvesting**

Treatment	Soil pH (1:2.5)			
	S ₁	S ₂	S ₃	Mean
M ₁	5.54	5.60	5.62	5.59
M ₂	5.44	5.56	5.58	5.52
M ₃	5.58	5.61	5.83	5.67
M ₄	5.31	5.49	5.54	5.45
Mean	5.47	5.56	5.64	
	S	M	S × M	
F test	NS	NS	Sig	
S.Em.±	0.01	0.02	0.05	
CD @ 5%	-	-	0.15	
Treatment Details:				
Spacing		Organic Manure		
S ₁ - 50 × 30 cm		M ₁ – FYM @ 10 t /ha + 100:50:50 kg/ha NPK		
S ₂ - 50 × 45 cm		M ₂ - Vermicompost @ 5 t/ha		
S ₃ - 50 × 60 cm		M ₃ - Poultry Manure @ 4 t/ha		
		M ₄ - Neem cake @ 2 t/ha		

4.4.1.2 Effect organic manure (M):

The organic manure significantly influenced the pH of soil. The highest pH (5.67) was recorded with application of poultry manure @ 4 t/ha and lowest pH (5.45) was recorded with application of neem cake @ 2 tonnes /ha).

The trend of effect of organic manure on pH of soil in descending order is as follows,

$$M_3 > M_1 > M_2 > M_4$$

4.4.1.3 **Interaction effect** (S × M):

From the data presented in Table 20 it could be revealed that the interaction effect between spacing and organic manure was found significant with respect to pH of soil. However, the highest pH (5.83) was observed with treatment combination S₃M₃. The lowest pH (5.31) was recorded with treatment combination S₁M₄.

The trend of interaction effect on pH of soil in descending order was as follows,

$$S_3M_3 > S_3M_1 > S_2M_3 > S_2M_1 > S_3M_2 = S_1M_3 > S_2M_2 > S_3M_4 = S_1M_1 > S_2M_4 > S_1M_2 > S_1M_4$$

The maximum pH with respect to spacing might be attributed due to the the small particle size improvement in soil pH was recorded in wider spacing 50 × 60 cm. Similar results related to soil pH were reported by Katiyar *et al.* (2014) in coriander. Further, with respect to organic manure the maximum soil pH reported with treatment M₃ might be due to poultry manure increased soil pH. Similar results related to soil pH were reported by Ewulo *et al.* (2008) in tomato. The similar trends also been reported in interaction effect of different spacing and organic manure.

4.4.2 **EC** (dSm⁻¹)

Soil EC being an important indicator of soil health, as it controls plant nutrient availability and activity of soil microorganisms which ultimately affects plant yield. Soil EC is a meaningful indicator of water quality as well as soil salinity and fertilizer concentration.

The data presented in table 21 represented effect of spacing, organic manure and their interaction on soil EC. The data showed significant effect on soil EC (dSm⁻¹).

4.4.2.1 Effect of spacing (S):

Effect of spacing on EC present in soil showed significant variation. The highest EC (0.21 dSm⁻¹) was recorded with treatment S₁. However, the lowest EC (0.13 dSm⁻¹) was recorded with treatment S₃.

The trend of effect of spacing on EC of soil in descending order is as follows,

$$S_1 > S_2 > S_3$$

Table: 21. **Effect of spacing and organic manure on EC (dSm⁻¹) of soil after harvesting**

Treatment	EC (dSm ⁻¹)			
	S ₁	S ₂	S ₃	Mean
M ₁	0.22	0.18	0.14	0.18
M ₂	0.17	0.15	0.11	0.14
M ₃	0.23	0.20	0.17	0.20
M ₄	0.21	0.15	0.12	0.16
Mean	0.21	0.17	0.13	
	S	M	S × M	
F test	Sig	Sig	Sig	
S.Em.±	0.001	0.001	0.003	
CD @ 5%	0.002	0.003	0.008	
Treatment Details:				
Spacing		Organic Manure		
S ₁ - 50 × 30 cm		M ₁ – FYM @ 10 t /ha + 100:50:50 kg/ha NPK		
S ₂ - 50 × 45 cm		M ₂ - Vermicompost @ 5 t/ha		
S ₃ - 50 × 60 cm		M ₃ - Poultry Manure @ 4 t/ha		
		M ₄ - Neem cake @ 2 t/ha		

4.4.2.2 Effect of organic manure (M):

The data regarding the EC showed significant variation with respect to different organic manure. The highest EC (0.20

dSm⁻¹) was recorded with treatment M₃. While, the lowest EC (0.14 dSm⁻¹) was recorded with treatment M₄.

The trend of effect of organic manure on EC of soil in descending order is as follows,

$$M_3 > M_1 > M_4 > M_2$$

4.4.2.3 **Interaction effect** (S × M):

Interaction between spacing and organic manure on EC showed significant differences. The highest EC (0.23 dSm⁻¹) was recorded with treatment combination S₁M₃ which was at par with S₁M₁ (0.22 dSm⁻¹) while S₃M₂ (50 × 60 cm with 2 t/ha neem cake gave the minimum EC (0.11 dSm⁻¹) which was at par with S₃M₂ (0.12 dSm⁻¹).

The trend of interaction effect on EC of soil in descending order was as follows,

$$\underline{S_1M_3} > \underline{S_1M_1} > S_1M_4 > S_2M_3 > S_2M_1 > S_1M_2 = S_3M_3 = S_2M_2 = S_2M_4 > S_3M_1 > S_3M_4 \geq \underline{S_3M_2}$$

Similar results with respect to spacing were obtained by Katiyar *et al.* (2014) in coriander whereas, with respect to organic manure M₃ recorded higher EC further, with respect to organic manure similar results were obtained by Joshi *et al.* (2016) in cowpea. The similar trends also been reported in interaction effect of different spacing and organic manure with respect to EC.

4.4.3 **Available nitrogen** (kg/ha)

Nitrogen is a vitally important plant nutrient. It is one of the main chemical elements required for plant growth and photosynthesis. Being a constituent of protein and chlorophyll, it

is necessary for all important processes of plant life. In Indian spinach, it is the chief promoter of growth.

4.4.3.1 **Effect of spacing (S):**

The data regarding the available nitrogen showed significant differences with respect to spacing. The highest available nitrogen (333.20 kg/ha) was recorded with spacing 50 × 60 cm (S₃) However, the lowest available nitrogen (318.41 kg/ha) was recorded with spacing 50 × 30 cm (S₁).

The trend of effect of spacing on available nitrogen of soil in descending order is as follows,

$$S_3 > S_2 > S_1$$

4.4.3.2 **Effect of organic manure (M):**

The data related to the available nitrogen showed significant variation with respect to different organic manure. The highest available nitrogen (327.94 kg/ha) was recorded with application of poultry manure @ 4 t/ha. Whereas, the lowest available nitrogen (320.42 kg/ha) was recorded with application of vermicompost @ 5 t/ha.

The trend of effect of organic manure on available nitrogen of soil in descending order is as follows,

$$M_3 > M_1 > M_4 > M_2$$

4.4.3.3 **Interaction effect (S × M):**

Interaction between spacing and organic manure on available nitrogen content showed significant differences. The highest available nitrogen (335.55 kg/ha) was recorded with treatment combination S₃M₃ while, lowest available nitrogen (313.28 kg/ha) was recorded in S₁M₄.

The trend of interaction effect on available nitrogen of soil in descending order was as follows,

$$S_3M_3 > S_3M_1 > S_3M_4 > S_3M_2 > S_2M_3 > S_2M_1 > S_1M_3 > S_1M_1 > S_2M_4 > \\ S_1M_2 > S_2M_2 > S_1M_4$$

The similar results with respect to spacing and organic manure on available nitrogen were revealed that Ewulo *et al.* (2008) and Katiyar *et al.* (2014) in tomato and Joshi *et al.* (2016) in cow pea.

4.4.4 **Available phosphorus** (kg/ha)

Phosphorus is an essential macro element, required for plant nutrition. It participates in metabolic processes such as photosynthesis, energy transfer and synthesis and breakdown of carbohydrates. Phosphorus helps to produce a strong root system in Indian spinach.

4.4.4.1 **Effect of spacing** (S):

The data regarding the available phosphorus in soil showed significant variation with respect to spacing. The highest available phosphorous (16.03 kg/ha) was recorded with treatment S₃. However, the lowest available phosphorus (12.97 kg/ha) was recorded with treatment S₁.

The trend of effect of spacing on available phosphorus of soil in descending order is as follows,

$$S_3 > S_2 > S_1$$

4.4.4.2 **Effect of organic manure** (M):

The related to available phosphorus is varied significantly. The highest available phosphorus (14.91 kg/ha) was recorded with treatment M₃. However, the lowest available phosphorus (13.99 kg/ha) was recorded with treatment M₄.

The trend of effect of organic manure on available phosphorus of soil in descending order is as follows,

$$M_3 > M_2 > M_1 > M_4$$

4.4.4.3 **Interaction effect** (S × M):

Interaction between spacing and organic manure on available phosphorus content showed significant differences. The highest available phosphorus (16.40 kg/ha) was recorded with treatment combination S₃M₃ while, the lowest available phosphorus (12.60 kg/ha) was recorded with treatment combinations S₁M₄.

The trend of interaction effect on available phosphorus of soil in descending order was as follows,

$$S_3M_3 > S_3M_2 > S_3M_1 > S_3M_4 > S_2M_3 > S_2M_2 > S_2M_1 > S_2M_4 > S_1M_3 > S_1M_2 > S_1M_1 > S_1M_4$$

The similar results with respect to spacing and organic manure on available nitrogen were revealed that Ewulo *et al.* (2008) and Katiyar *et al.* (2014) in tomato and Joshi *et al.* (2016) in cow pea.

4.4.5 **Available potassium** (kg/ha)

Potassium the third of three element in healthy soil nutrition, can greatly increase crop yields. It aids in water absorption and retention, also encourages strong roots, sturdy stems and healthy, full grown crops that have longer shelf life.

4.4.5.1 **Effect of spacing** (S):

The scrutiny of results on effect of spacing on available potassium implies that the available potassium showed significant effect under different spacing. The highest available potassium (359.89 kg/ha) was recorded with treatment S₃. However, the lowest available potassium (336.04 kg/ha) was recorded with treatment S₁.

Table: 22. **Effect of spacing and organic manure on available nitrogen, available phosphorus and available potassium (kg/ ha) after harvesting**

	Soil analysis											
Treatment	Available Nitrogen (kg/ha)				Available Phosphorus (kg/ha)				Available Potassium (kg/ha)			
	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean	S ₁	S ₂	S ₃	Mean
M₁	320.27	323.63	334.55	326.15	12.73	14.20	15.93	14.29	338.87	351.40	358.66	349.64
M₂	317.54	314.22	329.50	320.42	13.12	14.50	16.23	14.62	335.50	350.58	361.14	349.08
M₃	322.53	325.74	335.55	327.94	13.43	14.90	16.40	14.91	341.22	352.84	361.41	351.82
M₄	313.28	319.22	333.19	321.90	12.60	13.80	15.57	13.99	328.57	346.71	358.35	344.54
Mean	318.41	320.70	333.20		12.97	14.35	16.03		336.04	350.38	359.89	
	S	M	S × M		S	M	S × M		S	M	S × M	
F test	Sig	Sig	Sig		Sig	Sig	Sig		Sig	Sig	Sig	
S.Em.±	0.02	0.03	0.09		0.01	0.010	0.030		0.14	0.18	0.55	
CD @ 5%	0.07	0.09	0.28		0.02	0.029	0.087		0.40	0.53	1.60	

The trend of effect of spacing on available potassium of soil in descending order is as follows,

$$S_3 > S_2 > S_1$$

4.4.5.2 **Effect of organic manure (M):**

The data on available potassium under different organic manure showed significant variation. The highest (349.64 kg/ha) was recorded with treatment M_3 while, lowest available potassium (344.54 kg/ha) was recorded with treatment M_4 .

The trend of effect of organic manure on available potassium of soil in descending order is as follows

$$M_3 > M_1 > M_2 > M_4$$

4.4.5.3 **Interaction effect ($S \times M$):**

Interaction between spacing and organic manure on available potassium content showed significant differences. The highest available potassium content (361.41 kg/ha) was recorded with treatment combination S_3M_3 which was at par with S_3M_2 (361.14 kg/ha) while, S_1M_4 recorded lowest potassium (328.57 kg/ha).

The trend of interaction effect on available potassium of soil in descending order was as follows,

$$S_3M_3 > S_3M_2 > S_3M_1 > S_3M_4 > S_2M_3 > S_2M_1 > S_2M_2 > S_2M_4 > S_1M_3 > \\ S_1M_1 > S_1M_2 > S_1M_4$$

The similar results with respect to spacing and organic manure on available nitrogen were revealed that Ewulo *et al.* (2008) and Katiyar *et al.* (2014) in tomato and Joshi *et al.* (2016) in cow pea.

CHAPTER -V

SUMMARY AND CONCLUSION

The present investigation entitled “effect of spacing and organic manure on growth and yield performance of Indian spinach (*Basella rubra* L.).” was conducted at experimental field, College of Horticulture, Dapoli, Dist. Ratnagiri during *kharip* and *summer* season, 2019-2020 with following objectives:

1. To study the effect of spacing on growth and yield of Indian spinach
2. To study the effect of organic manure on growth and yield of Indian spinach
3. To find out the optimum spacing and organic manure for maximization of yield of Indian spinach

The method of experimentation and the respective findings of investigation are summarized and concluded below.

The experiment was laid out in Split Plot Design with three main treatments *i.e.* spacing S₁ (50 × 30 cm), S₂ (50 × 45 cm), S₃ (50 × 60 cm) and four sub- treatments *i.e.* organic manure levels M₁ (FYM @ 10 t/ha + 100:50:50 kg/ha NPK), M₂ (Vermicompost @ 5 t/ha), M₃ (Poultry manure @ 4 t/ha) and M₄- (Neem cake @ 2 t/ha). Thus, in all 12 treatment combinations replicated thrice.

The data obtained during the present investigation was statistically analyzed as per the methods prescribed by Panse and Sukhatme (1995). The results were obtained from the experiment during the course of present investigation are

summarized and concluded in this chapter under the following headings and sub headings.

5.1 Effect of spacing

5.2 Effect of organic manure

5.3 Interaction effect

5.1. **Effect of spacing**

5.1.1 **Growth parameters**

The growth parameters *viz.*, plant height, stem diameter, number of leaves, inter-nodal length, number of branches and leaf area varied significantly among various spacing except number of branches.

At 45 DAS, treatment S₁ recorded significantly highest plant height (22.14 cm), whereas stem diameter (9.38 mm) and inter-nodal length (1.81 cm) was recorded with treatment S₃. The highest number of leaves (22.40) and leaf area (114.29 cm²) was recorded with treatment S₂. The lowest inter-nodal length (1.46 cm) and stem diameter (8.42 mm) was recorded with treatment S₁. The lowest number of leaves (17.85) and leaf area (92.06 cm²) were recorded with treatment S₁ whereas, lowest plant height (17.69 cm) was recorded with treatment S₃.

At 75, 105, 135, 165, 195 and 225 DAS the highest plant height (30.63, 32.57, 35.07, 40.68, 49.53 and 51.05 cm respectively) highest stem diameter (10.46, 11.33, 12.54, 13.48, 14.69 and 16.78 mm respectively) and inter-nodal length (2.06, 2.66, 2.52, 2.62, 2.54 and 3.55 cm respectively) was observed in wider spacing S₃ (50 × 60 cm). Whereas, the highest number of branches (4.57, 5.35, 7.68, 9.36, 10.38 and 12.47 respectively),

number of leaves (44.69, 55.42, 60.40, 57.62, 56.19, and 52.61 respectively) and leaf area (192.76, 230.48, 238.93, 237.50, 231.07 and 238.82 cm² respectively) was noticed in optimum spacing S₂ (50 × 45 cm). Whereas, the lowest plant height (24.67, 26.78, 31.53, 33.84, 42.26 and 47.59 cm respectively), internodal length (1.71, 1.79, 2.13, 2.30, 2.25 cm and 2.45 cm respectively), stem diameter (9.62, 10.47, 11.47, 12.33, 13.05 and 14.02 mm respectively), number of leaves (40.65, 50.73, 55.80, 50.29, 50.50 and 48.33 respectively), and leaf area (172.38, 213.36, 219.19, 211.75, 202.51 and 215.51 cm² respectively) and number of branches (6.26, 7.89, 9.06 and 9.41 respectively) was found in closer spacing S₁ (50 × 30 cm). Except at 75 and 105 DAS the lowest number of branches (3.51 and 4.20) were observed in wider spacing S₃.

5.1.2 **Yield parameters:**

Various yield parameters *viz.*, herbage yield per plant (g), herbage yield per plot (kg), total herbage yield per plant (g), total herbage yield per plot (kg) and total herbage yield per hectare (t) showed significant difference among all the spacing tried under investigation.

At 45, 75, 105, 135, 165, 195 and 225 DAS the highest herbage yield per plant (21.63, 52.95, 69.14, 78.18, 88.38, 95.95 and 109.71 g respectively) and total herbage yield per plant (406.23 g) was observed with treatment S₃. However, the highest herbage yield per plot (1.96, 2.47, 3.04, 3.75, 4.15, 4.44 and 5.14 kg respectively), total herbage yield per plot (24.95 kg) and total herbage yield per hectare (27.72 t) was observed with treatment S₁. The lowest herbage yield per plant (19.40, 51.94, 68.67, 75.63, 85.04, 93.89 and 107.74 g respectively) and total

herbage yield per plant (394.56 g) was found with closer spacing S_1 (50 × 30 cm). However, the herbage yield per plot (0.96, 1.22, 1.56, 1.86, 2.06, 2.18 and 2.60 kg respectively), total herbage yield per plot (12.42 kg/ha) and total herbage yield per hectare (13.81 t/ha) was observed with wider spacing S_3 (50 × 60 cm).

5.1.3 **Quality parameters:**

The quality parameters *viz.*, vitamin A and ascorbic acid had recorded non-significant difference but dry matter content and shelf life of Indian spinach had observed significant difference among all the spacing tried under investigation.

The maximum dry matter (14.81 %) and shelf life (33.58 hours) was recorded with spacing S_3 (50 × 60 cm). The lowest dry matter (11.77%) and shelf life (29.50 hours) was recorded with S_1 (50 × 30 cm).

5.1.4 **Soil analysis (after harvesting)**

The soil parameters *viz.*, soil pH, EC, available nitrogen, available phosphorous and available potassium had recorded significant difference among all the spacing tried under investigation.

The highest soil pH (5.64), available nitrogen (333.20 kg/ha), available phosphorous (16.03) and available potassium (359.89 kg/ha) was recorded with spacing 50 × 60 cm whereas, the highest EC (0.21 dSm⁻¹) was recorded with spacing 50 × 30 cm. However, the lowest soil pH (5.47), available nitrogen (318.41 kg/ha), available phosphorous (12.97 kg/ha) and available potassium (336.04 kg/ha) was recorded with spacing

50 × 30 cm whereas, the lowest EC (0.0.13 dSm⁻¹) was recorded with spacing 50 × 60 cm.

5.2 Effect of organic manure

5.2.1 Growth parameters

The growth parameters *viz.*, plant height, stem diameter, number of leaves, inter-nodal length, and leaf area varied significantly with various spacing, except number of branches.

At 45, 75, 105, 135, 165, 195 and 225 DAS the highest plant height (21.46, 28.73, 31.86, 36.16, 41.55, 49.33 and 50.64 cm respectively), stem diameter (9.59, 11.22, 12.58, 13.59, 14.65, 15.49 and 17.63 mm respectively), inter-nodal length (1.74, 2.04, 2.49, 2.53, 2.76, 2.64 and 3.37 cm respectively), number of leaves (24.44, 45.19, 56.11, 55.38, 59.80, 57.39 and 55.59 respectively), number of branches (4.28, 5.03, 7.55, 9.08, 10.43 and 11.72 respectively) and leaf area (120.33, 193.78, 234.58, 246.77, 251.20, 233.42 and 240.15 cm² respectively) were observed with treatment M₁ (FYM @ 10 t /ha + 100:50:50 kg/ha NPK). Whereas, the lowest plant height (18.55, 27.18, 27.91, 29.69, 32.74, 41.57 and 47.00 cm respectively), stem diameter (8.46, 9.22, 9.64, 10.59, 11.62, 12.67, and 13.66 respectively) number of leaves (16.62, 39.83, 50.04, 48.10, 48.57, 48.79 and 45.62 respectively), inter-nodal length (1.47, 1.70, 2.02, 2.13, 2.20, 2.14 and 2.54 cm respectively), number of branches (3.75, 4.47, 6.54, 8.16, 9.19 and 10.79 respectively), and leaf area (85.17, 169.82, 210.05, 215.54, 206.47, 195.43 and 213.73 cm² respectively) was found with treatment M₄ (neem cake @ 2 t/ha).

5.2.1 Yield parameters

Various yield parameters *viz.*, herbage yield per plant (g),

herbage yield per plot (kg), total herbage yield per plant (g), total herbage yield per plot (kg) and total herbage yield per hectare (t) showed significant difference among all the organic manure tried under investigation.

At 45, 75, 105, 135, 165, 195 and 225 DAS the highest herbage yield per plant (21.47, 53.30, 69.48, 77.43, 87.30, 95.59 and 109.49 g respectively) and total herbage yield per plant (404.58 g) also, the highest herbage yield per plot (1.57, 2.00, 2.60, 2.99, 3.62, 3.66, 4.32 kg respectively), total herbage yield per plot (20.75 kg/ha) and total herbage yield per hectare (23.05 t/ha) was observed with treatment M₁ i.e. (FYM @ 10 t /ha + 100:50:50 kg/ha NPK). The lowest herbage yield per plant (19.75, 51.42, 68.38, 77.01, 86.43, 94.74 and 108.28 g respectively), total herbage yield per plant (397.73 g), the herbage yield per plot (1.28, 1.63, 2.13, 2.46, 2.50, 2.80, 3.27 kg/ha respectively), total herbage yield per plot (16.06 kg/ha) and total herbage yield per hectare (17.85 t/ha) was observed with application of neem cake @ 2 t/ha i.e. (M₄).

5.2.3 Quality parameters:

The quality parameters *viz.* vitamin A, ascorbic acid, dry matter content and shelf life of Indian spinach had observed significant differences among all the organic manure applied under investigation.

The highest vitamin A (3.71 mg/100 g) and dry matter (14.88 %) was recorded with treatment M₁. Whereas, the highest ascorbic acid (68.67 mg/ 100 gm) and shelf life (33.33 hours) was recorded with treatment M₃. The lowest vitamin A (3.35 mg/100 gm) and ascorbic acid (62.93 mg/100gm) was recorded

with treatment M₂. However, the lowest dry matter (11.28 %) and shelf life (30.33 hours) were recorded with treatment M₄.

5.2.4 **Soil analysis (after harvesting)**

The soil parameters *viz.*, soil pH, EC, available nitrogen, available phosphorous and available potassium had recorded significant difference among all the spacing tried under investigation.

The highest soil pH (5.67), EC (0.20 dSm⁻¹) available nitrogen (327.94 kg/ha), available phosphorous (14.91 kg/ha) and available potassium (351.82 kg/ha) was recorded with application of poultry manure @ 4 t/ha. However, the lowest soil pH (5.45), and available potassium (344.54 kg/ha) was recorded with application of neem cake @ 2 t/ha. While, lowest EC (0.14 dSm⁻¹) and available nitrogen (320.42 kg/ha), was recorded with application of vermicompost @ 5 t/ha whereas, the lowest available phosphorous (14.29 kg/ha) was recorded with application of FYM @ 10 t/ha + 100:50:50 kg/ha NPK.

5.3 **Interaction effect:**

5.3.1 **Growth parameters**

The growth parameters *viz.*, plant height, stem diameter, number of leaves, inter-nodal length and leaf area varied significantly among various spacing and organic manure combinations except number of branches.

At 45, 75, 105, 135, 165, 195 and 225 DAS the highest stem diameter (10.52, 11.74, 12.98, 14.44, 15.57, 16.68 and 19.86 mm) and inter-nodal length (1.89, 2.18, 2.74, 2.67, 3.13, 2.86 and 4.13 cm) was observed with treatment combinations S₃M₁ (50 × 60 cm with 10 t/ha FYM + 100:50:50 kg NPK).

However, the number of leaves (26.20, 47.77, 58.73, 58.47, 62.67, 60.67 and 58.18 respectively), number of branches (4.83, 5.67, 8.03, 9.74, 10.88 and 12.74 respectively) and leaf area (137.17, 206.31, 243.31, 254.23, 262.23, 246.22 and 253.32 cm² respectively) were observed with treatment combinations S₂M₁. Except 45 DAS, the highest plant height (23.25 cm) was observed with treatment combinations S₁M₁. Whereas at remaining interval *i. e.* 75, 105, 135, 165, 195 and 225 DAS, the highest plant height (31.77, 34.14, 37.98, 44.50, 51.67 and 53.35 cm respectively) was observed with treatment combination S₃M₁. The lowest stem diameter (8.26, 8.87, 9.24, 10.11, 10.69, 11.93 and 12.44 mm), number of leaves (14.77, 37.80, 47.90, 46.40, 45.60, 45.67 and 43.07 respectively), inter-nodal length (1.05, 1.48, 1.30, 1.93, 2.14, 2.05 and 2.19 cm respectively), number of branches (3.71, 4.36, 5.53, 7.48, 8.33 and 8.77 respectively) and leaf area (78.67, 162.09, 201.74, 205.51, 192.56, 179.55 and 207.60 cm² respectively) were found with treatment combination S₁M₄. Except 45 DAS, the lowest plant height (16.34 cm) and lowest number of branches (3.20 and 3.58) at 75 and 105 DAS was observed in treatment combination S₃M₄. Whereas, at remaining interval *i. e.* 75, 105, 135, 165, 195 and 225 DAS, the lowest plant height (24.33, 24.39, 28.45, 31.01, 38.70 and 46.26 cm respectively) was observed with treatment combination S₁M₄.

5.3.2 Yield parameters

Various parameters *viz.*, herbage yield per plant (g), herbage yield per plot (kg), total herbage yield per plant (g), total herbage yield per plot (kg) and total herbage yield per hectare (t)

showed significant difference among all the spacing tried under investigation.

At 45, 75, 105, 135, 165, 195 and 225 DAS the highest herbage yield per plant (22.27, 53.92, 69.96, 78.31, 88.57, 96.21 and 110.14 g respectively) and total herbage yield per plant (409.23 g) was observed with S₃M₁. However, the highest herbage yield per plot (2.10, 2.72, 3.46, 4.10, 5.34, 4.96 and 5.87 kg respectively), total herbage yield per plot (28.55 kg) and total herbage yield per hectare (31.72 t) was observed in S₁M₁. The lowest herbage yield per plant (18.59, 51.28, 68.32, 75.41, 84.46, 93.12 and 107.18 g respectively) and total herbage yield per plant (391.18 g), herbage yield per plot (0.85, 1.07, 1.39, 1.68, 1.92, 1.86 and 2.21 kg/ha respectively), total herbage yield per plot (10.98 kg) and total herbage yield per hectare (12.20 t) was observed with treatment combinations S₃M₄.

5.3.2 **Quality parameters:**

The quality parameters *viz.*, vitamin A, ascorbic acid, had observed non-significant difference among interactions tried under investigation except dry matter content and shelf life of Indian spinach.

The highest dry matter (16.42 %) was recorded in treatment combinations S₃M₁ whereas, highest shelf life (36.00 hours) was recorded with treatment combination S₃M₃. The lowest dry matter (9.36 %) and shelf life (28.00) was recorded with treatment combination S₁M₄.

5.2.3 **Soil chemical properties (after harvesting)**

The soil parameters *viz.*, soil pH, EC, available nitrogen, available phosphorous and available potassium had recorded

significant difference among interaction tried under investigation.

The highest soil pH (5.83), available nitrogen (335.55 kg/ha), available phosphorous (16.40 kg/ha) and available potassium (361.41 kg/ha) was recorded with treatment combination S₃M₃. However, the highest EC (0.23 dSm⁻¹) was recorded with treatment combination S₁M₃. However, the lowest soil pH (5.31), available nitrogen (313.28 kg/ha), available phosphorous (12.66 kg/ha) and available potassium (328.57 kg/ha) was recorded with treatment combination S₁M₄. While, lowest EC (0.11 dSm⁻¹) was recorded with treatment combination S₃M₂.

Conclusion:

From the present investigation entitled “effect of spacing and organic manure on growth and yield performance of Indian spinach (*Basella rubra* L.)” it was concluded that among different organic manure tried, FYM @ 10 t/ ha + 100:50:50 kg/ha NPK was found best as compared to remaining organic manure treatment. Further, closer spacing *i.e.* (50 × 30 cm) was recorded best as compared to other combinations which positively influenced the growth, and yield parameters.

The highest yield was obtained with closer spacing S₁ (50 × 30 cm). Indian spinach suggesting, closer plant spacing is best for getting more returns in terms of yield. Better physiochemical characters were observed with spacing S₃ in Indian spinach crops under study. Thus it is, evident that the wider spacing improved the physiochemical parameters in Indian spinach crops under study.

In yield attributing characters S_1 (50 × 30 cm) recorded better performance as compared to S_2 and S_3 , whereas better physiochemical properties were recorded with spacing S_3 (50 × 60 cm).

In case of organic manure higher yield attributes recommended with application of FYM @ 10 t/ ha + 100:50:50 kg/ha NPK in Indian spinach may also be attributed to satisfactory nutrient availability and increased plant metabolism which ultimately lead to more carbohydrates accumulation. Besides, there was increased vegetative growth at peak growth stages of the crop as observed in the study might have resulted in efficient production of photosynthetic and ultimately promoted higher yield. It is also evident that the manure M_1 improved the physiochemical parameters in Indian spinach under study.

In case of interaction effect the treatment combination S_3M_1 (50 × 60 cm along with FYM @ 10 t/ha + 100:50:50 kg/ha NPK) was observed as highest in physiochemical characters.

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APPENDIX-I ABBREVIATIONS

@ : At the rate of	m : Meter (s)
% : Percentage	mg : Milligrams
/ : per	MSL : Mean Sea Level
< : Less than	M. S : Maharashtra states
> : Greater than	q : Quintals
0° : Degree centigrade	NHB : National Horticulture Board
AGR: Average growth rate	No. : Number
Anon. : Anonymous	N : Nitrogen
C. D : Critical difference	NS : Non-significant
cm : Centimetre (s)	P : Phosphorus
cm ² : Centimeter ²	R I : Replication I
<i>et al.</i> , : and others	R II : Replication II
Fig : Figure	R III : Replication III
FYM : Farm yard manure	RGR: Relative growth rate
g : Gram (s)	S. E : Standard error
ha : Hectare (s)	SE.m : Standard error of mean
hrs: Hours	SIG : Significant
i.e. : that is	Sr. No. : Serial Number
kg : Kilograms	t : Tonne (s)
DAS : Days after sowing	µg : Micrograms
Wt. : weight	Viz., : namely

APPENDIX II
Weekly weather data during the period of study at Dapoli
(July 2019 to February 2020)

Period	MW	Tmax	Tmin	RH-I	RH-II	Wind speed	Rain	RD	BSS	Epan
		(°C)	(°C)	(%)	(%)	(Km/h)	(mm)	day	(hrs.)	(mm)
02.07 - 08.07	27	29.1	24.2	95	89	9.3	294.2	7	1.5	2.5
09.07 - 15.07	28	29.1	23.9	98	92	9.6	399.4	7	2.9	1.1
16.07 - 22.07	29	29.6	24.1	94	86	2.7	118.2	6	5.2	4.4
23.07 - 29.07	30	27.6	23.6	98	96	4.5	759.6	7	1.3	2.5
30.07 - 05.08	31	26.9	23.5	98	96	10.7	719.2	7	0.1	3.3
06.08 - 12.08	32	27.2	24.6	96	93	9.4	353.8	7	0.1	2.8
13.08 - 19.08	33	29.1	24.3	95	86	1.8	112.6	7	3.5	3.4
20.08 - 26.08	34	29.1	20.9	95	83	2.6	103.6	6	7.2	3.3
27.08 - 02.09	35	28.4	23.7	97	87	3.3	318.4	6	4.3	3.2
03.09 - 09.09	36	26.5	23.1	99	96	5.8	771.6	7	0.0	2.0
10.09 - 16.09	37	28.3	23.8	97	90	3.4	167.2	7	2.8	3.1
17.09 - 23.09	38	29.1	24.1	95	86	2.9	53.4	6	4.5	2.9
24.09 - 30.09	39	29.7	23.4	93	85	2.1	55.0	3	5.4	3.8
01.10 - 07.10	40	30.7	22.7	92	75	1.6	0.2	0	8.9	4.0
08.10 - 14.10	41	31.7	19.8	94	71	1.3	29.8	2	7.6	3.7
15.10 - 21.10	42	31.7	23.0	89	73	0.5	63.4	3	4.7	2.9
22.10 - 28.10	43	28.8	21.9	94	79	1.9	61.2	5	2.6	2.1
29.10 - 04.11	44	31.9	22.0	90	67	2.3	2.6	1	8.3	3.8
05.11 - 11.11	45	31.0	21.5	94	71	2.5	9.6	1	8.4	3.6
12.11 - 18.11	46	33.3	20.6	89	55	2.3	0.0	0	7.8	3.3
19.11 - 25.11	47	33.0	19.1	93	55	2.1	0.0	0	7.2	3.5
26.11 - 02.12	48	33.3	18.9	90.9	51.4	2.2	0.0	0	7.6	3.8
03.12 - 09.12	49	31.4	20.1	91	57	2.7	0.0	0	6.1	3.2
10.12 - 16.12	50	31.8	17.4	92	58	2.4	0.0	0	9.2	3.4
17.12 - 23.12	51	32.1	17.1	93	56	2.3	0.0	0	7.9	3.9
24.12 - 31.12	52	31.8	18.8	92	60	2.2	0.0	0	7.3	3.5
01.01 - 07.01	1	29.4	13.9	91	55	3.0	0.0	0	9.4	3.2
08.01 - 14.01	2	31.1	16.6	92	58	2.9	0.0	0	8.8	3.3
15.01 - 21.01	3	29.5	12.7	94	57	3.4	0.0	0	9.5	3.6
22.01 - 28.01	4	33.4	15.7	92	51	2.9	0.0	0	9.7	3.7
29.01 - 04.02	5	28.3	12.7	94	54	3.1	0.0	0	9.5	3.5
05.02 - 11.02	6	30.1	13.1	93	55	3.3	0.0	0	9.0	3.7
12.02 - 18.02	7	34.4	16.0	92	45	3.0	0.0	0	7.2	4.4
19.02 - 25.02	8	34.6	15.2	90	45	3.0	0.0	0	9.5	4.6
26.02 - 04.03	9	34.9	14.3	89	48	3.4	0.0	0	10.1	4.7

