Evaluation of intercrop and their pattern in onion seed crop

By

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(2017A75M)

Thesis submitted to the Chaudhary Charan Singh Haryana Agricultural University in the partial fulfillment of the requirement for the degree of

MASTER OF SCIENCE
IN
HORTICULTURE- VEGETABLE SCIENCE

DEPARTMENT OF VEGETABLE SCIENCE

CCS HARYANA AGRICULTURAL UNIVERSITY

HISAR- 125004, HARYANA, INDIA

2021

CERTIFICATE-I

This is to certify that this thesis entitled *Evaluation of intercrop and their pattern in onion seed crop* submitted in partial fulfilment of the requirement for the degree of Master of Science in the subject of Horticulture- Vegetable Science to the Chaudhary Charan Singh, Haryana Agricultural University, Hisar, is a record of bonafide research work carried out by **Nitesh Kumar,** Admission No. 2017A75M**,** under my supervision and that no part of this thesis has been submitted for any other degree.

The assistance and help received during the course of investigation have been fully acknowledged.

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CERTIFICATE-II

This is to certify that this thesis entitled *Evaluation of intercrop and their pattern in onion seed crop* submitted by **Nitesh Kumar,** Admission No. **2017A75M,** to Chaudhary Charan Singh Haryana Agricultural University, Hisar in partial fulfilment of the requirement for the degree of Master of Science in the subject of Horticulture- Vegetable Science has been approved by the Student's Advisory Committee after an oral examination on the same, in collaboration with external examiner.

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It is certified that the thesis submitted by Mr. **Nitesh Kumar,** Admissions No. **2017A75M**, M.Sc. Student of this department has been checked and found as per specification of the format circulated by the Dean, PGS vide his Memo No. PGS/A-1/09/6926-90 dated 26.08.09''

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ACKNOWLEDGEMENTS

Every effort is motivated by an ambition and all ambition have inspiration behind. I owe this pride place to my ever loving father (Mr. Narayan Singh) and Mother (Mrs. Kanta Devi) for their oceans of love and moral support bestowed upon me which steered the life of this cipher to the present shape. With extreme humble sense regards, I bow down my head to my beloved parents whose blessings, immense patience and encouragement were the constant source of inspiration, which made the task to success.

In an acstasy of delight, I express my profound sense of gratitude and indebtedness to my esteemed Major Advisor Dr. Surender Kumar Dhankhar, Principal Scientist ,Vegetable Science, College of Agriculture , CCSHAU, Hisar for his guidance, keen interest, constant endeavor and incessant encouragement, ever helping attitude and amicable behavior during the course of investigation, which brought out this surmount task to success. For all his affection and expertise guidance, I am beholden to him in a special manner and words fail to convey my respect, love and regard for him.

I exhibit my ingenious regards and heartfelt gratitude to the elite members of my Advisory Committee members Dr. Vinod Kumar Batra, Principal Scientist, Deptt. of Vegetable Science (Major Subject), Dr. Satish Kumar, Project Director, Directorate of Research, Deptt. of Agronomy (Minor Subject), Dr. V. S. Mor, Astt. Scientist, Deptt. of SST (Supporting Subject) and Dr. K. K. Kundu, Assoc. Prof., Deptt. of Agricultural Economics (Dean, PGS Nominee), for their constructive criticism, valuable suggestions, expertise guidance, keen interest and help rendered throughout the pursuit of this study.

I am also obliged to Dr. A. K. Bhatia HOD of Deptt. of Vegetable Science for his valuable suggestion and timely help during the course of this study.

Help and cooperation rendered by all teachers and office staff members of Department of Vegetable Science during the present endeavour is duly acknowledged.

I also express my sincere gratitude to CCSHAU for providing financial assistance during my study.

From the core of my heart, I owe my affectionate gratitude to my beloved sisters Preeti and Sandhya, brother-in-law Amit and Ravi, brother Surjeet Singh and my classmates Saleem Malik, Pankaj, Navnesh Reddy, Ram Dass, Shubham, Tajinder, Surendra, Deepak Mehra and my seniors Dr. Shantanu Mishra, Dr. Digamber Dhull, Dr. Neeraj and Dr. Ravi and my juniors Pawan, Sunil, Neeraj, Bintu and all relatives for their never ending love, affection, good wishes, moral support throughout my study period.

The instrument of acknowledgement would remain out of my tune if I do not express my thanks to the respondents who extended their cooperation during data collection.

Nehru library will always remain a luscious remembrance for furnishing my studies with endless and invaluable information.

At last, but not the least, I am thankful to all those who persuaded me to depict and accomplish my research task smoothly and rationally.

Place : Hisar
Dated : July, 2021 ***Nitesh Kumar***

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LIST OF ABBREVIATIONS

%	:	Percent
/	:	Per
°C	:	Degree Celsius
B:C	:	Benefit Cost
Cm	:	Centimeter
etc.	:	*Etcetra*
G	:	Gram
Ha	:	Hectare
i.e.	:	*id. est*. (that is)
Kg	:	Kilogram
L	:	Litre
Mg	:	Milligram
Mt	:	Metric tone
No.	:	Number
OEY	:	Onion Equivalent Yield
var.	:	Variety
viz.	:	*videlicet* (namely)
NS	:	Non significant

CHAPTER -I

INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important commercial vegetable crops cultivated extensively in India and it belongs to family Alliaceae. Onion is considered to be the second most important vegetable crop grown in the world after tomato. It is most widely grown and popular vegetable crop among the alliums as well as cash crops. It is semi perishable in nature and can be transported to a long distance without much injury. Onion is an indispensable item in every kitchen as condiment and vegetable and liked for its flavour and pungency because of a volatile oil 'allyl propyl disulphide'- organic compound rich in sulphur. Its bulbs are rich source of phosphorus, calcium and carbohydrates and also contains protein and vitamin C. It is being used in several ways as fresh, frozen, dehydrated bulbs and green bunching types. Onion has got good medicinal value. It contains several anti-cancerous agents, which have shown to prevent cancer in animals. The beneficial compound called 'quercetin' present in onion is a powerful antioxidant. Recently onion is being used by processing industry to greater extent for preparing dehydrated forms like powder and flakes.

Onion is native of middle Asia and is one of the basic and most widely consumed bulb vegetable crop. The bulb crop is planted in the month of December-January and July-August as rabi and kharif seasons crop respectively in northern plain region. Seed crop is planted in the month of October at a wider spacing (60 X 60 cm). It is grown for its culinary purposes and medicinal values. It contains eleven of the common amino acids and plays a vital part in preventing heart disease and other aliments (Auguisti and KT 1976). Onion contains carbohydrates (11.0 g), proteins (1.2 g), fiber (0.6 g), moisture (86.8 g) and several vitamin like vitamin A (0.012 mg), vitamin C (11 mg), thiamin (0.08 mg), riboflavin (0.01 mg) and niacin (0.2 mg) and also some minerals like phosphorus (39 mg), calcium (27 mg), sodium (1.0 mg), iron (0.7 mg) and potassium (157 mg) per 100 g (Rahman *et al*. 2013).

India is the second largest producer and third largest exporter of onion in the world contributes around 20.2 percent of world production. In India, during 2018-2019 onion was grown over an area of 12.63 lakh hectares with a production of 234.82 lakh tonnes. Maharashtra and Karnataka are the two leading states occupying more than half of the total area and contribute nearly 46 per cent of the total production of onion in India. The other important states with respect to onion production are, Gujarat, Bihar, Madhya Pradesh and Andhra Pradesh. (Agriculture Statistics at a Glance, 2019).

Seed is the basic unit of crop production and has a greater contribution than environment and cultural factors. India needs around 9400 tons of onion seed annually for covering 12.63 lakh

hectare area. The organized sector contributes around 54 per cent of the total requirement and rest is met by farmers own seed, often produced without meeting isolation requirement. There are two methods of onion seed production. Seed to seed and bulb to seed method; both can be used in seed production. But the bulb to seed is the most commonly used method in Ethiopia. This method has a number of merits; options of selection of bulbs of good size, uniform, typical color, free from diseases and physical damages. It produces several stalks per bulbs hence gives higher seed yield.

Beet leaf or *palak* (*Beta vulgaris* var. *bengalensis*) is one of the major leafy vegetable grown and consumed in India and can be grown in tropical and subtropical regions. It is native of Indo-Chinese region. It was known in China as early as 647 AD (Bharad, *et al. 2013*). In India this leafy vegetable commonly known as *Palak* and it is popular due to its high nutritive value.

The Palak growing states are Uttar Pradesh, West-Bengal, Haryana, Punjab, Delhi, Madhya-Pradesh, Bihar, Maharashtra, Rajasthan, Gujarat. However, this crop is now gaining popularity in southern states like Karnataka also.

Palak leaves are valued for their medicinal properties and are used in inflammation, paralysis, headache and remedy for diseases of spleen and liver, it also acts as mild lacerative besides other medicinal value, it supplies most of the nutrients in which other foods are deficient. Indian spinach is used as fresh vegetable for cooking and also in salad form. Palak is short duration and widely grown leafy vegetable and can be grown throughout the year but main crop is taken as winter crop, mainly sown in October-November at spacing of 15 x 5cm. Its leaves become ready for first cutting in about 35 days after sowing and subsequent cuttings are taken at 15-20 days interval. (Mishra *et al.*, 2003).

Fenugreek (*Trigonella foenum-graecum* L.), belongs to the family fabaceae is widely distributed throughout the world. Both leaves and seeds are extensively used for medicinal purpose. It is well known as traditional medicine for diabetes, indigestion, lipids elevation and edema (fluid retention) of the legs. Fenugreek is also a good source of dietary fibre, protein for human. Its seeds have a strong aroma and somewhat bitter in taste. Seeds of fenugreek are used locally as yellow dye in cosmetics. Fresh tender pods and leaves of fenugreek are rich in iron, calcium, vitamins A and C. Fenugreek is also used as a leafy vegetable which are rich in iron, calcium, vitamins and essential amino acids like lysine, leucine and phenylaniline. It has high proportion of protein (20-30%) as well as amino acids. Among amino acids, 4-hydroxyisoleucine has high potential as insulin stimulating agent (Ruveyde *et al*., 2011). In Northern India it is grown during Rabi season for leaves and seeds at a spacing of 20 x 10 cm. Fenugreek is a good soil renovator having property of nitrogen fixation and is widely used as green manure crop

The demand of vegetables is increasing day by day among people due to high income and awareness about their nutritional value vegetables being rich source of nutrients, vitamins, minerals, antioxidants, fibers, carbohydrates, *etc*. and medicinal value. Presently, availability of vegetables per day per capita is about 200 g, below the required quantity of

vegetables (300 g per head per day). Land holding is decreasing day by day due to urbanization, high population growth and industrialization across the country. Hence, the challenges are to produce more vegetables per unit area to fetch up the demand. Therefore, strategies should be to produce higher quantity of vegetables from less land with optimum use of water, fertilizers and by adopting suitable agronomical management practices like intercropping, mixed cropping, relay cropping, *etc*. are the options, which can be followed for higher production in per unit area.

Intercropping refers to growing two or more dissimilar crops simultaneously on the same piece of land. Crop intensification is in both time and space dimensions. It also helps the farmers for getting stable production and maintaining the soil fertility level. Intercropping system results in yield advantage because the component crops differ in their use of growth resources. When they are grown in combination, they are able to complement each other and *per se* make better overall use of resources than when grown separately. Many studies have indicated that intercropping with different vegetable was more productive and profitable than sole cropping because of complementary effects of intercrop (Varghese, 2000).

The strategy should be to produce more vegetables from less use of land and water with less detrimental to soil and environment as well. A very little work has been done on intercropping systems on *Onion, Palak* and *Fenugreek* in India and no recommendation on this aspect exists under Haryana conditions. Considering the above facts, the present investigation entitled *"Evaluation of intercrop and their pattern in onion seed crop"* was carried out at the Vegetable Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during rabi season, 2018-19 with the following objectives:

1. To find out the suitable intercropping and its pattern.
2. To work out the economics of different intercropping systems.

CHAPTER -II

REVEIEW OF LITERATURE

A comprehensive review of literature is an integral part of any investigation, as it not only gives an idea of the work done in the past and assists in delineation of problem area, but also provides basis for interpretation and discussion of the findings.

Many studies have shown that intercropping with different crops was more productive and profitable than sole cropping system due to complementary effects of intercrop (Varghese, 2000). Many researchers have reported that intercropping also influences the growth and yield of different vegetable crops including *Onion*, *Palak and Methi*. Since very scanty literature is available on the *"Evaluation of intercrop and their pattern in onion seed crop"* the research information on allied crops has also been included in this chapter.

The present chapter embodies a brief review of the research works done by several researchers in the country as well as abroad related to the topic. The purpose of reviewing the earlier works is not only to economize the historical perspective of the present work but also to understand the related studies, in which cognizance of one or more variables have been taken which were included in this study in a manner such that the resources of the short-coming and pit-falls observed in any earlier study may be checked.

Rahangdale *et al.* (1995) found the highest height of plant, leaf number and yield in sole cabbage crop (341.42 q/ ha) and the lowest yield in cabbage + radish (270.37 q/ ha), respectively. Usually there is lower yield in case of intercropping in comparison to sole crop but its economic benefit overcome the reduced yield as sole cabbage crop resulted in net return of Rs. 20485.20 ha^{-1} while in intercropping with radish to Rs. 29692.20 ha^{-1}

Gawade *et al.* (2003) found significantly higher yield and return in inter cropping combination of cauliflower + *palak* than intercrop of cauliflower + radish, cauliflower + coriander, cauliflower + methi and cauliflower + *shepu* and also from sole crop of cauliflower, radish, coriander, *palak*, methi and *shepu*.

Hussain (2003) reported that inter-copping combination of tomato + okra recorded maximum yield (27.61 t/ha) followed by tomato + eggplant (21.54 t/ha), whereas, tomato + potato recorded lowest yield (12.75 t/ha). On the other hand, tomato + okra recorded maximum harvest index value (78.10%) followed by tomato + eggplant (61.1%). Lowest harvest index value (49.8%) was obtained with sole crop of tomato (49.8%).

Hossain *et al.* (2003) evaluated the agronomic and economic performance of different intercrops *viz.,* onion (*Allium cepa*), potato (*Solanum tuberosum*) and sesame (*Sesamum indicum*) with sugarcane in paired row system. Sugarcane with potato followed by

second intercrop sesame produced the highest yield of cane, potato and sesame. The maximum number of tillers, millable cane, diameter of cane and days stalk weight were observed in the same crop combination.

Raji and Fadare (2003) reported that kenaf (*Hibiscus cannabinus* L.) is a potential intercrop with okra (*Abelmoschus esculentus* L.) in Nigeria. They suggested that each row of okra should be intercropped with one row of kenaf to maximize yield of both the crops.

Gawade *et al*. (2004) observed that the combined yield of cabbage + *palak* was significantly higher than the remaining crop combinations (cabbage + radish, cabbage + coriander, cabbage + methi and cabbage + shepu).

John and Mini (2005) recorded the highest total biomass production of okra in okra +cowpea intercropping system during *Kharif (*26328 kg/ha) and *Rabi* (27000 kg/ha) season of year 2000. Okra + cowpea at lower spacing (60 x 45 cm) gave maximum okra equivalent yield in both *Kharif* (7907 kg/ha) and *Rabi* (8709 kg/ha) seasons. The lowest okra equivalent yield with okra + amaranth system at higher spacing of 100 x 45 cm in both *Kharif* (1012 kg/ha) and *Rabi* (1314 kg/ha) seasons.

Obadoni *et al*. (2005) reported that different planting ratio in intercropping system of tomato and cowpea significantly affected plant growth in cowpea, however, tomato growth was similar at all combinations. Growing cowpea and tomato at 33/67 ratio gave a higher yield and consequently greater monetary returns than all other planting ratio (cowpea and tomato at 50/50 ratio and cowpea and tomato 67/33 ratio). In the mixtures, the yield of tomato was consistently greater in plots containing higher and equal proportion of tomato with cowpea, while cowpea yield was highest in its sole crop and also performed well when combined 67% cowpea with 33% tomato.

Mohamed *et al*. (2007) carried out a field trial where okra was planted at spacing of 70 x 40 cm. Cowpea or cucumber was planted at mid-distance between okra hills either simultaneously with okra or later after growing okra. Data indicate that okra-cowpea intercropping did not affect okra fruit yield. Cowpea, produced 257 kg ha-1 dry seed yield when planted simultaneously or 3 weeks after planting okra. With regard to cucumber, fruit yield was produced only when it was planted simultaneously with okra. Okra-cucumber intercropping based on simultaneous planting of both crops depressed okra pod yield to 90% of its monocrop yield.

Suresha *et al*. (2007) reported that the growth of chilli was affected by the intercrops with radish, carrot, onion, garlic, cluster bean and dolichot bean. Significantly the highest (75.16 q/ha) yield were obtained from sole chilli than different combinations of above crops with chilli. The plant height was comparatively higher in sole chilli (83.89 cm) and the lowest was recorded when chilli was intercropped with cluster bean (63.93 cm) at the stage of final harvest.

Manorama and Lal (2010) studied intercropping possibilities of French beans (*Phaseolus vulgaris* L.), maize (*Zea mays* L.) and wheat (*Triticum aestivum* L.) with potato (*Solanum tuberosum* L.) in three population proportions (75: 25, 75: 50 and 50: 50) under rainfed conditions on sandy clay loam soils of the Nilgiris. Potato equivalent yield (PEY) of potato + French bean at 75: 50 population was recorded significantly high (27.1 t/ha).

Mehta *et al*. (2010) observed that growth parameters, yield attributes and seed yield of coriander was higher with coriander + carrot intercrop in 1: 1 ratio. The highest coriander equivalent yield (2.11 t/ha) was exhibited by 1: 1 ratio followed by 2: 2 ratio. Coriander + carrot with all ratios gave higher coriander equivalent yield, over coriander intercropped with onion/garlic. Thus, coriander + carrot in 1: 1 ratio was best for realizing higher productivity and profitability under intercropping system.

Prashaanth *et al*. (2010) reported that brinjal fruit yield (8.89 kg/plot) was slightly higher when paired row planting of brinjal with two rows of groundnut followed by brinjal with groundnut in alternative rows (7.84 kg/plot). In case of intercropped groundnut, yield and yield components did not significantly differ among the treatments. However, 60/150 cm paired row of brinjal with two rows of groundnut would be the suitable planting geometry to obtain higher yield of brinjal in intercropping.

Singh and Kushwah (2012) reported that intercropping radish or spinach with potato reduced potato yield by 17% and 8%, respectively. This might be due to competition of potato with intercrop, leading to reduction yield per plant and reflected in total tuber yield.

Ahmed *et al.* (2013) conducted a field trial on intercropping of okra and leafy vegetables was conducted at Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur and Agricultural Research Station, Burirhat, Rangpur to find out suitable crop combination for higher productivity and economic return. In both the locations, sole okra produced the highest yields 15.82 t/ha at Joydebpur and 13.79 t/ha at Burirhat). Among the intercropping treatments, the highest okra yields (15.42 t/ha at Joydebpur and 12.64 t/ha at Burirhat) were obtained from okra 100%+ red amaranth 75% combination. The lowest okra yield (13.16 t/ha at Joydebpur and 11.75 t/ha at Burirhat) was recorded in okra 100% + jute as *patshak* 100% combination. The highest okra equivalent yield (23.00 t/ha) was recorded in okra 100% + red amaranth 100% at Joydebpur and in okra 100% + leaf amaranth 100% (21.79 t/ha) at Burirhat.

Duragannavar *et al*. (2013) conducted a field experiment at Agricultural Research Station, Devihosur in black clay soil under rainfed condition during 2004-05 and 2005-06. The treatments comprised of two chilli genotypes (cv. Byadagi Kaddi and Hy. 9646) with Jayadhar cotton as mixed crop (main plot) and six intercrops *viz.*, soybean, french bean, coriander (vegetable), coriander (seeds), garlic and onion (sub-plot). Chilli genotype Hy. 9646 recorded 1013 kg per ha (dry chilli yield) accounting for 37.4 per cent increase over chilli cv.

Byadagi (737.0 kg/ha). Intercropping of coriander (vegetable) with chilli + cotton recorded significantly higher dry chilli yield (1122 kg/ha). Growing chilli genotype cv. Byadagi with chilli + cotton recorded significantly higher chilli equivalent yield (cv. Byadagi) of 2189 kg per ha. Intercropping garlic with chilli + cotton system recorded significantly higher chilli equivalent yield (cv. Byadagi) of 3216 kg per ha. Intercropping garlic with chilli (cv. Byadagi) + cotton recorded highest chilli equivalent yield (cv. Byadagi) of 3257 kg per ha.

Islam *et al*. (2014) reported that the yield of brinjal was comparatively lower in intercropping but total productivity increased due to additional yield of leafy vegetables and legumes. The increases in total productivity in terms of brinjal equivalent yield (BEY) was 8.80 to 26.67 t/ha in intercrop combination compared to base crop.

Kumar *et al.* (2014) carried out a field experiment at Indira Gandhi Krishi Vishwavidyalaya, Raipur, (C.G.) during spring season to study the biological evaluation of crops under okra (*Abelmoschus esculentus* L. moench) based intercropping system. Okra was grown as main crop on plot with *palak*, fenugreek, greengram and radish as intercrop. Growth parameters and yield attributes of each crop were found relatively higher under sole cropping, which ultimately registered the maximum yield. Whereas among intercropping with okra, growth parameters and yield attributes of each crop were registered higher under 2: 3 paired rows, while seed yield of *palak*, fenugreek, greengram and root yield of radish were found higher under 1: 2 row ratio.

Paul *et al*. (2015) obtained the highest fruit yield (15.33 t/ha) of brinjal from the treatment in which two rows of coriander intercropped between two rows of brinjal and the lowest (3.00 t/ha) in sole brinjal.

Shima and Shalaby (2015) observed that sugar beet as sole crop produced the highest yield of root, sugar percentage and total sugar. Compare to combination of sugar beet + onion system, followed by sugar beet + garlic system.

Sujay and Giraddi (2015) recorded highest (3.86 q/ha) yield of dry chilli when intercropped with coriander and it was at par with chilli + onion (3.54 q/ha) intercrop. Whereas, intercrop yield was significantly highest in chilli + onion (15.56 q/ha) followed by chilli + soybean (9.99 q/ha).

Islam et al. (2016) obtained the highest brinjal yield (33.89 t/ha) in brinjal 100% + garlic 30% intercropping system, and the lowest yield (32.52 t/ha) in brinjal 100% + garlic 70% intercropping combination. The yield reduction of brinjal in intercropping combination was 2.02- 5.98% as compared to sole crop. The maximum reduction (5.98%) occurred in brinjal 100% + garlic 70% intercropping combination. The highest brinjal equivalent yield (91.65 t/ha) were in combination of brinjal 100% + garlic 70% compared to other intercropping combinations and sole crop of brinjal. Maximum fruit yield was in sole brinjal plot (34.59 t/ha) but statistically at par to intercropped combinations.

Mohammed and Mohsen (2016) reported that alternating one row of fennel or coriander with three rows of onion gave the highest values of growth parameters and yield per plant of apiaceous crops in the two seasons. The highest values of LER (land equivalent ratio), ATER (area time equivalent ratio), LUE (land utilization efficiency) and RCC (relative crowding coefficient) were (1.206 and 1.288), (1.126 and 1.207), (113.81 and 121.99%) and (2.552 and 4.033) in first and second seasons, respectively which were achieved by intercropping pattern of one row of coriander with two rows of onion.

Boori *et al*. (2017) revealed that planting of fennel and fenugreek in 1:1 row ratio recorded significantly maximum plant height of fenugreek at 40, 80 DAS and at final harvest, however, in case of dry matter accumulation at all growth stages, number of pods/plant and number of seeds/pod were significantly lowest as compared to 1:2 row ratio and sole crop of fenugreek. The fennel planting in 1:2 row ratios could not bring significant variation in growth parameters, yield attributes of fenugreek as compared to sole fenugreek.

Getahun, *et al.* (2018) revealed that in 2016/17 the highest yield was obtained from intercropping onion with Dill followed by rape seed, kale and black cumin, while the highest yield in 2017/18 was from intercropping onion with lentil, rape seed, kale and linseed. In general, intercropping onion with both crops considered in this study, except fenugreek, was found more advantageous than sole cropping. Intercropping onion with rapeseed, dill and kale was found more efficient than other intercrops.

Kumari, *et al.* (2019) studied the impact of intercropping and integrated nutrient management on yield and returns of chilli and found that all the intercrops except marigold positively influenced green and dry chilli yield of chilli over chilli sole crop. Chilli + fenugreek treatment recorded maximum values for yield and yield attributing parameters of ripe and dry chilli. The competitive functions like LER and ATER indicated that fenugreek and coriander were the better intercrops in chilli.

Effect of intercropping on economics

Least adverse effect on yield and greater cash return was observed when vegetables like radish, onion, tomato and brinjal were intercropped with *Rauvolfia serpentine* than from the single crop (Sahu, 1970).

Chavan *et al*. (1985) reported that intercrop of cabbage with *palak* had given the highest total returns (Rs. 20,367.0) per ha against the return of Rs.17,037 from the sole crop per ha.

Hussain (2003) reported that pea + radish intercropping system was the most economical. This combination gave significantly maximum net income of Rs. 181648/ha followed by Rs. 80800 /ha from pea -lettuce combination. Pea intercropped with spinach and potato remained least economical and resulted in the minimum net income of Rs. 432l5 and Rs. 44949 /ha, respectively.

Gawade *et al*. (2004) recorded the highest monetary return of Rs. 101760.43 in intercropping system of cabbage + pa1ak. John and Mini (2005) reported that highest net return of Rs 33,456 and Rs 43329 during *kharif* and *rabi* seasons, respectively in okra + cowpea intercropping at lower spacing of 60 x 45cm. The lowest net return of Rs 95391 and Rs 785 in *kharif* and *Rabi* seasons, respectively were recorded with okra + amaranthus system at higher spacing of 100 x 45cm.

Obadoni *et al.* (2005) found that growing cowpea and tomato in intercrop system was more economical than alone either of them. Replacement ratio at 33/67 cowpea-tomato mixture increased monetary returns by 8% and 54.5% compared to sole tomato and sole cowpea, respectively. The monetary returns from cowpea tomato mixture were controlled by tomato yield and price, while cowpea contributed very little to the income of the farmer except at 67/33 cowpea-tomato mixture.

Kumar *et al.* (2005) revealed that intercropping of maize and cowpea in the row proportion of 2:2 recorded significantly higher net returns (Rs. 8346/ha) over other treatments. However, B: C ratio of sole maize was higher (1.78) but it was *at par* with maize + cowpea planted in the row ratio of 2: 1 and 2: 2.

Parkash *et al*. (2007) found that the relay intercropping of maize (green cobs) + tomato + garden pea + french bean and maize (green cobs) + french bean + garden pea + french bean proved significantly superior in terms of net returns (Rs 2,39,558 and Rs 1,52,624/ha respectively) than maize (green cobs)-garden pea (Rs 48,020/ha) and french bean-garden pea (Rs 94,021/ha) sequential cropping. Whereas, the lowest maize net returns (Rs 48,020/ha) and economic efficiency (Rs 132/ha/day) were recorded under maize (green cobs)-garden pea sequential cropping. Relay intercropping of maize (green cobs) + tomato + garden pea + french bean proved the best in terms of monetary returns.

Suresha *et al*. (2007) reported that the highest net return (Rs. 59,261/ha) and B:C ratio (1.75) were obtained in chilli, which was intercroped with garlic. On the contrary, the lowest net returns (Rs. 12744) and B:C ratio (1.01) were obtained in sole chilli. This obviously reflected the significance of intercropping systems to enhance the productivity per unit area. Further, it also offers insurance against crop failure.

Mehta *et al*. (2010) observed that the highest net return (Rs 50,701/ha) and B: C ratio (2.16) was shown by 1:1 ratio followed by 2:2 ratio. Intercropping system of coriander + carrot with all ratios gave higher net return and benefit cost ratio over coriander intercropped with onion/garlic. Thus coriander + carrot in 1:1 ratio are best for realizing higher system productivity and profitability.

Ahmed *et al*. (2013) recorded the highest gross margin (Tk. 227180/ha) in combination of okra 100% + red amaranth 100% at Joydebpur and in okra 100% + leaf amaranth 100% at Burirhat (Tk. 214600/ha) with highest benefit cost ratio (5.66 at Joydebpur and 5.58 at Burirhat).

Islam *et al*. (2014) reported that brinjal 100% + Mungbean 60% was the most feasible and profitable intercropping system in respect of brinjal equivalent yield (20.85 t/ha), gross return (Tk.312750/ha), gross margin (Tk.212693/ha) and benefit cost ratio (3.13).

Kumar *et al.* (2014) found maximum Benefit: Cost ratio (Rs. 7.73) from intercropping of okra: radish at 2:3 paired rows and it was found more economical combination among different intercropping combinations. Maximum gross return (Rs. 187800/ha) and net returns (Rs. 165238/ha) was obtained from the intercropping of okra: radish at 1:2 row ratio.

Paul *et al*. (2015) reported that the highest gross return (Tk. 2,47050 ha $^{-1}$), gross margin (Tk. 1,35050 ha $^{-1}$) and benefit cost ratio BCR (2.21) were obtained from crop combination of 100% brinjal+ 50% coriander, while the lowest from sole brinjal crop.

Sujay and Giraddi (2015) obtained the highest net returns (Rs 70,709) with B:C ratio of 1:5.45 by growing cropping system of chilli + onion followed by chilli + coriander (Rs 51,207, BC ratio-1: 4.57) and chilli + onion + cotton (Rs 43,671).

Talukdar *et al*. (2015) observed that onion (100%) + 20% coriander gave the highest benefit cost ratio (BCR) of 5.01 and 4.92 in first and second year, respectively followed by sole onion 4.86 and 4.59, respectively while 100% onion + 50% coriander gave the lowest BCR of 3.50 and 3.37 during the first and second year, respectively.

Islam *et al*. (2016) reported that the highest gross return (Tk.1374800 ha^{-1}), gross margin (Tk.1003426 ha^{-1}) and BCR (3.70) were found in intercropping of brinjal 100% + garlic 70% compared to other intercropping combination and sole cropping of brinjal.

Singh *et al*. (2016) found that potato + radish intercrop resulted in higher relative net return (3.28) and benefit :cost ratio (6.38).

Kumari *et al.* (2019) studied the impact of intercropping and integrated nutrient management on yield and returns of chilli and obtained maximum gross and net returns in chilli + onion combination and lowest gross returns and B: C ratio obtained in chilli + marigold combination irrespective of INM treatments.

CHAPTER -III

MATERIALS AND METHODS

In order to study the *"Evaluation of intercrop and their pattern in onion seed crop"* the present investigation was conducted at the Vegetable Research Farm, Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during rabi season, 2018. The details of the experiment and methods employed during the course of present investigation are described under the following heads

3.1. Experimental site and climatic conditions

Hisar is located at 29° 10´ latitude north, 75° 46´ longitude east and 215.2 m above mean sea level with semi-arid subtropical climate. Hot and dry winds during summer and dry cold in winter are common features of this region. A maximum temperature around 48°C during summer and temperature up to freezing point accompanied by occurrence of frost during winter is common. The average rainfall is around 400 mm, most of which is received from Southwest monsoon during July to September. The meteorological data for maximum and minimum temperature (ºC), total rainfall (mm), relative humidity (%), bright hours of the day, wind speed and pan evaporation recorded during the crop season at the Meteorological Observatory located in Research Area of the Department of Meteorology, CCS Haryana Agricultural University, Hisar are presented in Table 3.1.

Table 3.1: **Monthly metrological observations of Hisar during October-May, 2018-19**

Month	Temperature (°C)		Relative Humidity		Average Wind Speed (Km/hr.)	Bright Sun Shine Hours	PAN Evaporation	Rainfall (mm)
	Max.	Min.	Max.	Min.				
Oct. 2018	32.9	17.2	83.1	37.4	3.4	7.2	3.6	0.0
Nov. 2018	28.1	11.7	90.6	45.7	2.7	4.0	2.1	0.0
Dec. 2018	21.6	4.8	93.4	50.1	2.0	4.8	1.2	0.0
Jan. 2019	18.8	5.2	94.7	61.7	2.9	4.2	1.0	1.3
Feb. 2019	21.0	8.4	91.9	56.4	4.5	5.1	1.7	3.7
March 2019	27.7	10.7	85.0	39.2	3.7	7.2	3.2	0.0
April 2019	36.6	18.4	70.1	27.6	5.0	7.7	6.5	2.1
May 2019	39.6	20.8	60.4	26.2	6.2	8.4	8.3	5.3

3.2. Physio-chemical properties of the soil

To know the physio-chemical composition of the experimental site, composite soil samples were taken from 0-15 and 15-20 cm depth from five places of the field and were analyzed which are presented in Table 3.2.

Table 3.2. Physical and chemical characteristics of the soil of the experimental field

Particulars	Depth (cm)		Method used
	0-15	15-30	
Texture	Sandy loam	Sandy loam	-
pH	8.13	8.26	pH metre with glass electrode in 1: 2 soil water suspension (Jackson, 1973)
EC (dsm^{-1})	0.26	0.21	Conductivity Bridge Method (USDA Hand Book No. 60, 1954)
Organic carbon (%)	0.48	0.29	Wet oxidation method (Jackson, 1967)
Available N ($kg\ ha^{-1}$)	158	148	Alkaline permanganate method (Subbiah and Asija, 1956)
Available P_2O_5 ($kg\ ha^{-1}$)	20.0	12.0	Olsen's method (Jackson, 1967)
Available K_2O ($kg\ ha^{-1}$)	251.6	196.2	Flame photometric method (Jackson,1973)

3.3. Experimental details

To fulfill the requirement of objectives of the investigation field experiment was conducted during *Rabi* season of 2018-19. A "Randomized Block Design" with ten treatments replicated thrice was adopted. The layout plan is shown in Figure 3.1 and details of treatments are given below:

Treatments		**Notation**
Onion seed crop (sole crop)	:	$\mathbf{T_1}$
Palak (sole crop)	:	$\mathbf{T_2}$
Methi (sole crop)	:	$\mathbf{T_3}$
Onion + Palak (1 row)	:	$\mathbf{T_4}$
Onion + Palak (2 rows)	:	$\mathbf{T_5}$
Onion + Palak (3 rows)	:	$\mathbf{T_6}$
Onion + Palak (Broadcast)	:	$\mathbf{T_7}$
Onion + Methi (1 row)	:	$\mathbf{T_8}$
Onion + Methi (2 rows)	:	$\mathbf{T_9}$
Onion + Methi (Broadcast)	:	$\mathbf{T_{10}}$

Onion was grown as main crop and Palak and Methi were grown as intercrops.

Name of varieties used

	Crop	Variety
1.	**Onion:**	Hisar onion-3 (HO-3)
2.	**Palak:**	HS-23
3.	**Methi:**	HM-57

Fertilizers (kg/ha):

(i) Recommended dose of fertilizers in sole crop of Onion & intercrop combination (N - 125 kg + P_2O_5 - 50 kg + K_2O - 25 kg)

(ii) Recommended dose of fertilizers in Palak sole crop (N 80 - kg + P_2O_5 - 40 kg)

(iii) Recommended dose of fertilizer in Methi sole crop (N - 25kg + P_2O_5 - 50 kg)

Experimental design: Randomized Block Design

Number of Replications: Three

Spacing:

60 × 60 cm for onion

15 × 5 cm for palak

20 × 10 cm for methi

Season: Rabi (2018-19)

3.4. Cultural operations adopted to raise healthy crop

3.4.1. Land preparation

The experimental field before preparing the seedbeds was thoroughly prepared by ploughing thrice followed by planking and leveling to bring the field to a good tilth. The ridges were made at 60 cm distance including ridge.

3.4.2. Planting

Mother bulbs were planted at 60 cm space between rows and 60 cm between plants on a row. Seeds of palak and methi were sown in between rows of onion crop as per treatment followed by irrigation. operations like hoeing, weeding, and plant protection measures were carried out as per the package of practices as and when required during entire course of study.

3.4.3. Irrigation

The crop was irrigated immediately after planting and sowing of palak and methi seeds, later the crop was irrigated 15-20 days intervals according to prevailing weather conditions.

3.4.4. Application of fertilizers

In case of onion sole crop & in intercrop combinations, full recommended doses of P_2O_5(50 kg/ha), K_2O(25 kg/ha) and ½ Nitrogen(62.5kg/ha) were applied as basal dose and remaining quantity of nitrogen was applied as top dressing in two split doses at 30 and 60 days after transplanting. In sole crop of palak and methi, recommended dose of P_2O_5 and ½ nitrogen was applied at the time of sowing and rest of the nitrogen was applied at 30 days after sowing.

3.4.5. Inter-cultural operations

First hoeing was done 25 days after transplanting. Subsequent weedings were carried out manually at 30 days interval.

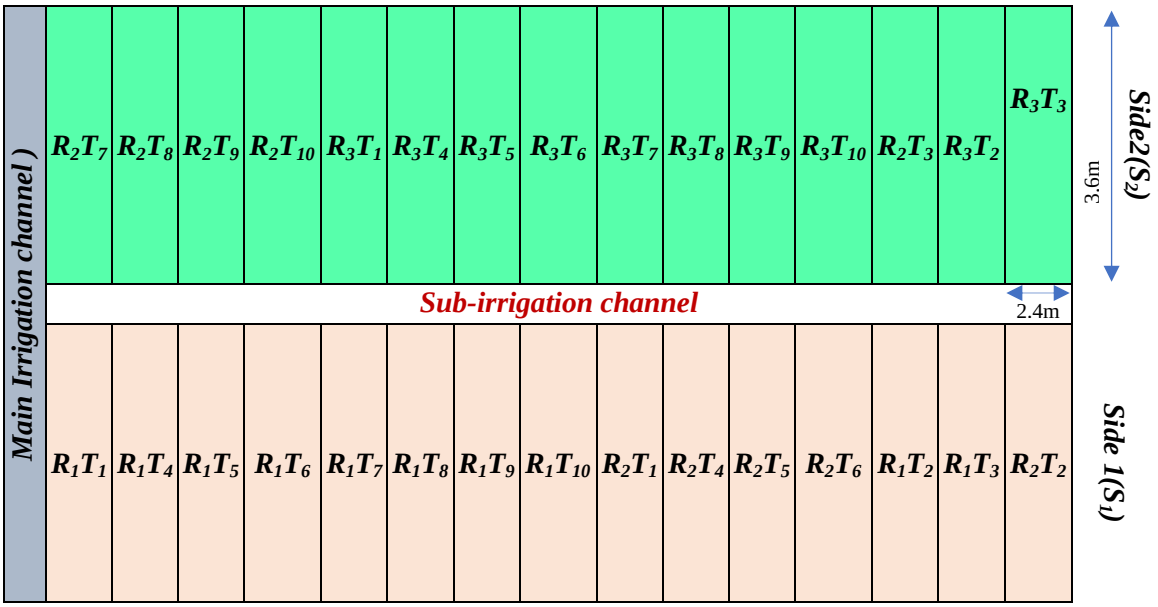
3.4.6. Harvesting

The first cutting of *palak* and *methi* leaves was done at 30 days after sowing and another two subsequent cuttings were taken at 20–25 days interval . In onion all umbels per plant do not mature at one time due to difference in the stalks to flowering; therefore, harvesting was done 3-4 times when about 50% black seeds were exposed on an umbel.

Design and layout of experiment

The experiment was laid out in a randomized block design, and the treatments were replicated three times randomly with a plot size of 3.6×2.4 m. The layout of the experiment is given in Figure 3.1.

Fig 3.1: Layout plan of Experimental Field



3.5. Observations recorded

Five competitive plants were selected randomly in each treatment per replication to record the data and were tagged to record the data on morphological and yield parameters as followed:

3.5.1. Onion crop

i. Days to 50% sprouting of bulbs

Number of days taken to sprout in 50% bulbs of the total bulbs planted were counted and their average is calculated is termed as days to 50% sprouting of bulbs.

ii. Plant height (cm) at each harvest of intercrops

The height of five randomly selected competitive onion plants was measured from base to apex using meter rod in centimeter at first, second and third cuttings of Palak and Methi. Height of all plants were summed up and their average was computed.

iii. Days to 50 % flowering

Number of days taken to flower by the 50% plants of the total number of plants from days of bulbs planted were counted. Number of days taken were summed and days to 50% flowering was calculated by dividing with number of plants and multiplying with 100.

iv. Number of seed stalks per bulb

The number of seed stalks of selected tagged plants in each treatment and replication was counted and the average number of seed stalks per bulb was worked out by dividing with number of plants.

v. Length of flower stalks (cm)

The length of flower stalks (cm) of five randomly selected plants were measured with scale in centimeter and their average worked out by dividing with number of flower stalks.

vi. Diameter of flower stalk (cm)

The diameter of flower stalk was measured with the help of Vernier calliper from five randomly selected plants and average worked out by dividing with number of flower stalks .

vii. Number of seeds per umbel

All umbels of five randomly selecte plants were counted and harvested. Seeds of all umbels were extracted and counted. Total number of seeds were divided by number of umbels to calculate number of seeds per umbel.

viii. Number of seeds per plant

All umbels of five randomly selected plants were harvested and their seeds were extracted. All seeds were counted and divided with number of plants to calculate seeds per plant.

ix. Seed weight per umbel (g)

Seeds were collected from each umbel of five randomly selected plants and weighed in grams, seed weight per umbel was calculated by dividing seed weight with number of umbels and reported as weight of seeds umbel^{-1}.

x. Seed weight per plant (g)

Seeds obtained from the five randomly selected plants were weighed in grams and seed weight per plant was estimated by dividing the weight with number of plants .

xi. Seed yield (q/ha)

The net plot area was harvested, plants were sun dried and seeds of all plants obtained from plot were threshed to record the seed yield plot^{-1}. Seed yield plot^{-1} was weighed in kilogram and converted into quintal hectare^{-1}.

xii. Test weight (g)

One thousand seeds were counted randomly from seed lot of a plot and weighed in gram to estimate test weight.

3.5.2. Palak crop

i. Leaf length (cm) (at each harvesting)

Randomly five leaves were taken from freshly harvested plot and from tip to base of length of each leaf was measured in centimeter then average value of leaf length in centimeter was calculated.

ii. Leaf Width (cm) (at each harvesting)

Width of five selected leaves was measured from the middle of each leaf with the help of meter scale and then average value in centimeter was determined.

iii. Petiole length (cm) (at each harvesting)

Petiole length of randomly selected five leaves was measured in centimeter with the help of meter scale and then average value was calculated.

iv. Fresh leaf yield of first, second, and third harvesting (q/ha)

Fresh leaf yield at first, second and third cuttings was recorded in kg/plot and computed in q/ha treatment wise separately.

v. Total leaf yield (q/ha)

Total leaf yield of each treatment was calculated as the average yield of first, second and final cutting.

3.5.3. Methi crop

i. Plant height (cm)

The plant height was measured in centimeter from the plant base to the base of apex leaf of five selected plants and their average was expressed as plant height in centimeters.

ii. Numbers of branches plant^{-1}

Numbers of branches plant^{-1} were counted from five randomly selected plants and number of branches per plant were averaged by dividing with number of plants.

iii. Fresh leaf yield of first, second and third harvesting (q/ha)

Fresh leaf yield per plot at first, second and third cuttings was recorded in kg and converted into q/ha.

vi. Total leaf yield (q/ha)

Total leaf yield of Methi was recorded in kg/plot and converted into q/ha.

3.6 Onion equivalent yield

It was calculated as the yield of onion sole crop, which could be produced by utilizing monetary value, which was obtained from onion + *palak* and onion + methi intercropping system. It was calculated by using the below given formula:

$$\text{Onion equivalent yield} = \frac{Y_o + Y_p \times P_p}{P_o}$$

Where,

Y_o = Yield of onion in intercropping system (q/ha)

Y_p = Yield of *palak* in intercopping system (q/ha)

P_o = Price of onion seed (Rs/q)

P_p = Price of *palak* (Rs)

And,

$$\text{Onion equivalent yield} = \frac{Y_o + Y_m \times P_m}{P_o}$$

Where,

Y_O = Yield of onion in intercropping system (q/ha)

Y_m = Yield of *methi* in intercopping system (q/ha)

P_o = Price of onion (Rs/q)

P_m = Price of *methi* (Rs)

3.7 Economic analysis

3.7.1 Cost of cultivation

Cost of cultivation of individual treatment (sole crop and intercrop combination of onion, palak and methi crops) was calculated on the basis of local charges of labour, input and cultural operations applied to raise healthy crops.

3.7.2 Gross return

The seed yield of onion and leaf yield of palak and methi was converted in to gross return (Rs ha^{-1}) on the basis of local market price of onion seed and green leaves of Palak and Methi.

3.7.3 Net return

Net return (Rs ha^{-1}) of crop produce was calculated by subtracting the cost of cultivation of each crop from gross return.

3.7.4 Benefit cost ratio

Benefit to cost ratio (BCR) takes into account the amount of monetary gain realized by performing an experiment versus the amount it costs to execute the experiment. Higher the BCR, better is the investment. B: C ratio was computed by below given formula:

$$\text{BCR} = \frac{Net\ return\ (\text{Rs /ha})}{cost\ of\ cultivation\ (\text{Rs/ha})}$$

3.8 Statistical analysis

In order to test the significance of result, standard statistical method based on the analysis of variance technique as suggested by Panse and Sukhatme (2000) were employed. The treatments differences were compared with the critical difference (CD) at 5% level of significance to ascertain their significance; all the results have been summarized in the suitable tables presented under "Experimental Findings" given the means of treatments. Suitable Illustrations of the data have also been made at appropriate places.

The critical difference (C.D.) was calculated with the help of following formula:

$$\text{Standard Error of mean (SEm} \pm) = \sqrt{\frac{VE}{r}}$$

$$\text{Critical difference (C.D.)} = \sqrt{\frac{2\,V_E}{r}} \times \text{ 't' value at 5\% level of significance for error df.}$$

Where C.D. = Critical Difference

V_E = MSS of Error (Error variance)

r = Number of observations averaged

't' = 't' value from fisher's table for error degree of freedom at 5% level of probability.

Table 3.3: **Analysis of variance**

Source	Degrees of freedom	Sum of squares	Mean sum of squares	F calculated value
Replication	r-1	SSr	MSr	MSr/MSe
Treatment	t-1	SSt	MSt	MSt/MSe
Error	(r-1) (t-1)	SSe	MSe	
Total	n-1	TSS		

Where,

r = Number of replications

t = Number of treatments

MSr, MSt and MSe stand for mean sum of square due to replication, treatment and error, respectively.

3.9 Presentations of data

The data for the various characters studied have been summarized and presented in suitable tables. To depict the treatment differences analysis of variance tables are furnished in appendices. As is customary, the significant results have also been marked with on asterisk.

CHAPTER -IV

EXPERIMENTAL RESULTS

The experiment entitled *"Evaluation of intercrop and their pattern in onion seed crop"* carried out at Research farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during *Rabi* season of 2018-19. The data recorded for different parameters during the course of study were compiled, tabulated and subject to statistical analysis. The obtained results are presented in tabular form and described as follow.

4.1. Onion crop

4.1.1. Days to 50% sprouting of bulbs

The data pertaining to days to 50% sprouting of bulbs are presented in Table 4.1. The respective data were analyzed statistically and analyses of variance for days to 50% sprouting of bulbs are presented in Appendix I.

Table 4.1 Effect of different planting combinations on days to 50% sprouting of bulbs in onion + intercropping system

Treatments	Days to 50% sprouting of bulbs
T_1 - Onion seed crop (Sole crop)	5.33
T_4 - Onion + Palak (One row)	5.33
T_5 - Onion + Palak (Two rows)	5.33
T_6 - Onion + Palak (Three rows)	6.00
T_7 - Onion + Palak (Broad-cast)	5.67
T_8 - Onion + Methi (One row)	5.67
T_9 - Onion + Methi (Two rows)	6.00
T_{10} - Onion + Methi (Broadcast)	6.00
SEm±	0.28
CD (P = 0.05)	NS

The data presented in Table 4.1 revealed that days to 50% sprouting of bulbs practically unaffected due to different intercropping systems and it ranged from 5.33 to 6.00 days after planting.

4.1.2. Plant height of onion (cm) at each harvest of intercrops

The statistically analyzed data and analysis of variance for plant height are presented in Appendix II. The data recorded on height of onion plants at first, second and third harvesting of intercrops (Palak and Methi) as influenced by sole cropping and different intercropping system are given in Table 4.2.

Table 4.2 Effect of intercropping system on plant height of onion (cm)

Treatments	Plant height of onion (cm) at		
	1st harvesting of palak and methi	2nd harvesting of palak and methi	3rd harvesting of palak and methi
T_1 - Onion seed crop (Sole crop)	29.84	78.60	84.45
T_4 - Onion + Palak (One row)	28.93	75.63	81.30
T_5 - Onion + Palak (Two rows	28.52	73.20	80.13
T_6 - Onion + Palak (Three rows)	28.07	72.85	79.32
T_7 - Onion + Palak (Broad-cast)	27.63	72.54	77.14
T_8 - Onion + Methi (One row)	28.73	75.60	81.28
T_9 - Onion + Methi (Two rows)	28.62	75.07	80.53
T_{10} - Onion + Methi (Broadcast)	27.54	72.67	77.05
SEm±	0.36	0.96	1.03
CD (P = 0.05)	1.08	2.90	3.13

The perusal of data reveals that plant height of onion continued to increase with advancement of crop age. The plant height ranged from 27.54 cm in onion + methi (broadcast) treatment to 84.45 cm in onion (sole crop) treatment at third harvesting. Tallest plants of onion were observed in onion + palak one row (28.93, 75.63 and 81.30 cm) at 1st, 2nd and 3rd harvesting respectively in intercropping systems in all the three-harvestings followed by onion + methi one row (28.73, 75.60 and 81.28 cm) at 1st, 2nd and 3rd harvesting respectively, which was at par with all the rest intercropping treatments except onion + palak broadcasting (27.63, 72.54 and 77.14 cm) at 1st, 2nd and 3rd harvesting respectively and onion + methi broadcasting (27.54, 72.67 and 77.05 cm) at first, second and third harvesting respectively. The minimum plant height was observed in onion + methi broadcasting (27.54, 72.67 and 77.05 cm) at first, second and third harvesting respectively followed by onion + palak broadcasting (27.63, 72.54 and 77.14 cm) at 1st, 2nd and 3rd harvesting respectively at all the three harvesting. The maximum plant height of onion was recorded with onion sole crop (29.84, 78.60 and 84.45 cm) at 1st, 2nd and 3rd harvesting respectively, which was significantly higher than all the intercropping treatments at first, second and third harvesting of inter crop.

4.1.3. Days to 50% flowering

The data pertaining to days taken for 50 per cent flowering have been presented in Table 4.3 and their analysis of variance are given in Appendix III.

Table 4.3 Effect of different planting combinations on days to 50% flowering in onion + intercropping system

Treatments	Days to 50 % flowering
T_1 - Onion seed crop (Sole crop)	135.00
T_4 - Onion + Palak (One row)	135.00
T_5 - Onion + Palak (Two rows	135.33
T_6 - Onion + Palak (Three rows)	135.00
T_7 - Onion + Palak (Broad-cast)	135.67
T_8 - Onion + Methi (One row)	135.00
T_9 - Onion + Methi (Two rows)	135.00
T_{10} - Onion + Methi (Broadcast)	135.00
SEm±	0.33
CD (P = 0.05)	NS

A critical examination of Table-4.3 revealed that different intercropping system and sole crop did not differ significantly among themselves in respect of number of days required to 50 per cent flowering. About 135-136 days were taken for 50 per cent flowering of onion in all the treatments of inter cropping as well as sole crop.

4.1.4. Number of seed stalks bulb^{-1}

The data pertaining to number of seed stalks bulb^{-1} of sole crop and different intercropping combinations are given in Table 4.4. The number of seed stalks bulb^{-1} was significantly influenced in various intercropping treatments.

Table 4.4 Effect of different planting combinations on number of seed stalks bulb^{-1}, length of flower stalks (cm) and diameter of flower stalk (cm) of onion.

Treatments	No. of seed stalks bulb^{-1}	Length of flower stalks (cm)	Diameter of flower stalk (cm)
T_1 - Onion seed crop (Sole crop)	9.87	106.00	2.42
T_4 - Onion + Palak (One row)	9.33	105.60	2.33
T_5 - Onion + Palak (Two rows	8.96	104.00	2.24
T_6 - Onion + Palak (Three rows)	8.60	102.80	2.21
T_7 - Onion + Palak (Broad-cast)	8.00	101.67	2.08
T_8 - Onion + Methi (One row)	8.68	104.13	2.11
T_9 - Onion + Methi (Two rows)	8.32	102.46	2.09
T_{10} - Onion + Methi (Broadcast)	7.70	101.60	1.96
SEm±	0.11	1.19	0.03
CD (P = 0.05)	0.35	3.62	0.08

Number of seed stalk bulb^{-1} significantly decreased with increase in palak and methi population rows between onion. The range obtained for number of seed stalks bulb^{-1} varies from 7.70 to 9.87. The highest number of seed stalks bulb^{-1} (9.87) was recorded with onion seed crop (Sole crop). The lowest value of this character was recorded in onion + methi broadcasting (7.70).

4.1.5. Length of flower stalk (cm)

The perusal of data in table 4.4 indicated that onion in onion + palak (one row) intercropping system did not differ appreciably with onion+ palak (two and three row) and onion + methi (one and two row), but had significantly higher length of flower stalks than onion + palak and onion + methi broadcasting. The range obtained for length of flower stalks varies from 101.60 cm to 106.00 cm. The highest length of flower stalks (106.00 cm) was recorded in onion seed crop (Sole crop) and lower value (101.60 cm) of this character was observed in onion + methi broadcasting.

4.1.6. Diameter of flower stalks (cm)

The data pertaining to diameter of flower stalks (cm) influenced by sole cropping and different intercropping treatments are presented in Table 4.4. Diameter of flower stalks of

onion in onion + palak one row combination was significantly highest than rest intercropping system with palak and methi. The higher diameter of flower stalks (2.42 cm) was recorded for onion seed crop (sole crop) followed by onion + palak (one row) (2.33 cm) and lower values of this character was observed in onion + methi broadcasting (1.96 cm). This indicated that with the increase in population of intercrop crops resulted in decrease of stem diameter due to nutrients and space competition.

4.1.7. Number of seeds umbel^{-1}

The data recorded on number of seeds umbel^{-1} as influenced by sole cropping and different intercropping systems are presented in table 4.5.

Data indicated that number of seeds umbel^{-1} (1165.00 and 1158.67) of onion in onion + methi (one row) and onion+ palak (one row) intercropping, respectively were at par, but both the treatments resulted in significantly higher number of seeds umbel^{-1} in onion than rest of the intercropping treatments, which did not differ significantly among themselves. The higher of number of seeds umbel^{-1} (1198.33) was recorded with onion seed crop (sole crop) and lower value of this character was observed in onion + palak broadcasting (1103.67).

Table 4.5 Effect of different planting combinations on number of seeds umbel^{-1} and seed weight umbel^{-1} of onion

Treatments	Number of seeds umbel^{-1}	Seed weight umbel^{-1} (g)
T_1 - Onion seed crop (Sole crop)	1198.33	4.15
T_4 - Onion + Palak (One row)	1158.67	3.98
T_5 - Onion + Palak (Two rows	1118.33	3.82
T_6 - Onion + Palak (Three rows)	1109.33	3.80
T_7 - Onion + Palak (Broad-cast)	1103.67	3.64
T_8 - Onion + Methi (One row)	1165.00	3.96
T_9 - Onion + Methi (Two rows)	1120.07	3.80
T_{10} - Onion + Methi (Broadcast)	1106.00	3.62
SEm±	12.70	0.05
CD (P = 0.05)	38.51	0.14

4.1.8. Seed weight umbel^{-1}

Magnitude of the main effects of different treatments are summarized in Table 4.5.

The forgoing table reveals that the maximum seed weight umbel^{-1} (4.15 g) was recorded with onion sole crop, which was significantly higher than rest of the intercropping treatments. The lowest seed weight (3.62g) was observed with onion + methi broadcasting intercropping system. Further, data indicates that one row of palak (3.98g) and methi (3.96g) with onion one row was at par and both the treatments produced significantly higher seed weight umbel^{-1} than rest of the treatments, which did not differ appreciably among themselves.

4.1.9. Number of seeds plant^{-1}

The data recorded on number of seeds plant^{-1} as affected by sole cropping and different intercropping treatments are summarized in Table 4.6.

Table 4.6. Effect of different planting combinations on the number of seeds plant^{-1} and seed weight plant^{-1} (g) of onion

Treatments	Number of seeds plant^{-1}	Seed weight plant^{-1} (g)
T_1 - Onion seed crop (Sole crop)	8253.33	26.45
T_4 - Onion + Palak (One row)	7960.00	24.86
T_5 - Onion + Palak (Two rows	7487.67	23.18
T_6 - Onion + Palak (Three rows)	7285.33	23.16
T_7 - Onion + Palak (Broad-cast)	6621.33	21.56
T_8 - Onion + Methi (One row)	7985.67	24.88
T_9 - Onion + Methi (Two rows)	7538.00	23.20
T_{10} - Onion + Methi (Broadcast)	7029.67	21.58
SEm±	86.27	0.86
CD (P = 0.05)	261.66	1.64

Maximum number of seeds per plant (8253.33) was found in onion sole crop, which was significantly high over rest of the treatments. The number of seeds plant^{-1} (7985.67) in intercropping combination of onion + methi (one row) was at par with onion + palak (one row) (7960), but both the treatments produced significantly higher number of seeds plant^{-1} then rest of the treatments. Onion + palak (two rows) intercropping did not differ appreciably with onion + methi (two rows) and both the treatments produced significantly higher number of seeds per plant produced significantly higher number of seeds per plant than onion + palak and onion+ methi broadcasting.

4.1.10. Seed weight plant^{-1}

The data indicated that onion sole crop produced significantly higher seed weight plant^{-1} (26.45g) than rest of the treatments. The seed weight plant^{-1} of onion + palak one row (24.86g) intercropping did not differ appreciably with onion + methi one row (24.88g), but both the intercropping systems produced significantly higher seed weight than rest of the treatments. Onion + palak in one and two rows and onion + methi two rows had increased seed weight plant^{-1} over onion + palak and onion + methi broadcasting.(Table 4.6)

4.1.11. Seed yield (q ha^{-1})

The perusal of data revealed that onion sole crop resulted in conspicuously more seed yield ha^{-1} (6.16 q ha^{-1}) than rest of the treatments. The combination of onion + palak (one row) intercropping produced seed yield ha^{-1} (5.78 q ha^{-1}) was at par with onion + methi (one row)(5.76 q ha^{-1}), however both treatments had significantly higher seed yield than the rest of the treatments. Onion + palak in one and two rows and onion + methi two rows increased seed yield over onion + palak and onion + methi broadcasting.(Table 4.7)

Table 4.7 Effect of different planting combination on seed yield ha^{-1} and test weight of onion

Treatments	Seed yield (q ha^{-1})	Test weight (g)
T_1 - Onion seed crop (Sole crop)	6.16	3.85
T_4 - Onion + Palak (One row)	5.78	3.82
T_5 - Onion + Palak (Two rows	5.56	3.80
T_6 - Onion + Palak (Three rows)	5.48	3.79
T_7 - Onion + Palak (Broad-cast)	5.35	3.78
T_8 - Onion + Methi (One row)	5.76	3.84
T_9 - Onion + Methi (Two rows)	5.54	3.84
T_{10} - Onion + Methi (Broadcast)	5.32	3.81
SEm±	0.07	0.05
CD (P = 0.05)	0.21	NS

4.1.12. Test weight (1000 seed weight)

The data pertaining to test weight (g) as influenced by sole cropping and different intercropping systems are given Table 4.7. The data indicate that test weight (g) did not influenced significantly due to different intercropping systems. However, the higher test weight was recorded for onion seed sole crop (3.85g) while lowest was obtained with onion + palak broadcasting (3.78 g).

4.2. Palak crop

4.2.1. Leaf length of palak (cm)

The perusal of data reveals that leaf length continued to increase with the advancement of crop age i.e from 1st harvesting to 3rd harvesting. Leaf length decreased with the increase in number of rows of palak as intercrop with onion at each harvest (Table 4.8).

Table 4.8. Effect of different onion + palak intercropping combinations on length of leaf (cm) of palak.

Treatments	Leaf length of palak (cm)		
	1st harvesting	2nd harvesting	3rd harvesting
T_2 - Palak (sole crop)	16.20	17.13	17.20
T_4 - Onion + palak (one row)	15.42	16.05	16.45
T_5 - Onion + palak (two rows)	14.82	15.38	15.70
T_6 - Onion + palak (three rows)	14.25	14.72	14.95
T_7 - Onion + palak (Broadcast)	13.67	14.07	14.17
SEm±	0.17	0.19	0.22
CD (P = 0.05)	0.55	0.63	0.72

Longest length of palak leaf was observed in sole palak crop (16.20, 17.13 and 17.20 cm) at 1st, 2nd and 3rd harvesting respectively, which was significantly higher than other intercropping combinations. The leaf length of palak in treatment onion + palak (one row) (

15.42, 16.05 and 16.45 cm) at 1st, 2nd and 3rd harvesting respectively was recorded significantly longer than other intercropping system.

4.2.2. Petiole length of palak (cm)

Table 4.9. Effect of different onion + palak intercropping combinations on petiole length (cm) of palak at different harvesting

Treatments	Petiole length (cm)		
	1st harvesting	2nd harvesting	3rd harvesting
T_2 - Palak (sole crop)	12.53	13.27	13.86
T_4 - Onion + palak (one row)	12.27	12.78	13.28
T_5 - Onion + palak (two rows)	12.13	12.70	13.25
T_6 - Onion + palak (three rows)	9.93	10.74	10.94
T_7 - Onion + palak (Broadcast)	9.57	10.23	10.94
SEm ±	0.16	0.18	0.20
CD (P = 0.05)	0.53	0.58	0.66

Petiole length continued to increase with the decrease in plant population and advancement of crop age. The petiole length was found maximum (13.86 cm) in sole palak in third harvesting and minimum (9.57 cm) in onion + palak (Broadcast) combination.

The petiole length in intercropping system increased gradually with the decreased of plant population. The petiole length significantly varied among various intercropping treatments at first, second and third harvesting. Palak sole crop showed maximum petiole length (12.53, 13.27 & 13.86 cm) at every harvest. Within the intercropping system, the maximum petiole length (12.27, 12.78 & 13.28 cm) was observed in treatment onion + palak (one row), which was at par with onion + palak (two rows) (Table 4.9).

4.2.3. Leaf width of palak (cm)

Table 4.10. Effect of different onion + palak intercropping combinations on leaf width (cm) of palak at different harvesting

Treatments	Leaf width (cm)		
	1st harvesting	2nd harvesting	3rd harvesting
T_2 - Palak (sole crop)	7.13	9.07	9.23
T_4 - Onion + palak (one row)	7.03	9.00	9.07
T_5 - Onion + palak (two rows)	6.98	8.76	8.83
T_6 - Onion + palak (three rows)	6.92	8.68	8.73
T_7 - Onion + palak (Broadcast)	6.82	8.67	8.68
SEm±	0.35	0.42	0.45
CD (P=0.05)	NS	NS	NS

The perusal of data indicated that leaf width continued to increase with the advancement of crop age. From 1st harvest to 3rd harvest the leaf width of palak ranged from 6.82 cm in onion + palak (Broadcast) at 1st harvest to 9.23 cm in sole crop at third harvest. There was non-significant difference among different intercropping combinations for leaf width at first, second and third harvesting (Table 4.10).

4.2.4. Palak leaf yield of 1st, 2nd and 3rd harvesting and total leaf yield (q ha^{-1})

The leaf yield of palak was significantly affected by various intercropping treatments at first, second and third harvesting. The data indicated that leaf yield of palak continued to increase with advancement of crop age. The leaf yield ranged from 22.10 q ha^{-1} in onion + palak (Broadcast) at first harvesting to 47.15 q ha^{-1} in palak sole crop at third harvesting.

Leaf yield of palak under different intercropping combinations increased gradually with the increase in number of rows of palak (1 to 3 rows). The leaf yield significantly varied among various intercropping system at first, second and third harvesting. Palak sole crop produced highest leaf yield at all the harvesting stages.

Table 4.11 Effect of different onion + palak intercropping combinations on leaf yield (q ha^{-1}) of palak at different harvesting and total leaf yield

Treatments	Leaf yield (q ha^{-1})			
	1st harvesting	2nd harvesting	3rd harvesting	Total leaf yield
T_2 - Palak (sole crop)	31.62	35.28	47.15	114.5
T_4 - Onion + palak (one row)	24.28	29.37	41.42	95.07
T_5 - Onion + palak (two rows)	25.35	30.56	42.38	98.29
T_6 - Onion + palak (three rows)	30.72	34.15	46.05	110.93
T_7 - Onion + palak (Broadcast)	22.10	27.32	39.50	88.92
SEm±	0.34	0.50	0.66	1.50
CD (P=0.05)	1.12	1.62	2.14	4.90

Within the treatment of intercropping the maximum leaf yield was obtained from onion + palak three rows, which was at par with sole palak. The minimum leaf yield was obtained from onion + palak (Broadcasting) followed by intercropping of single row of palak with onion. Similarly, the total leaf yield was recorded maximum for sole palak (114.5 q ha^{-1}) and onion + palak three rows (110.93 q ha^{-1}). Among the different intercropping treatments, the lowest leaf yield (88.92 q ha^{-1}) was obtained from onion + palak (Broadcast) treatment (Table 4.11).

4.3. Methi crop

4.3.1. Plant height of methi (cm) at each harvesting

The data recorded on plant height of methi at first, second and third harvest as affected by sole cropping and different intercropping have been presented in table 4.12.

Table 4.12 Effect of different onion + methi intercropping combinations on plant height of methi (cm) at different harvesting

Treatments	Plant height of methi (cm)		
	1st harvesting	2nd harvesting	3rd harvesting
T_3 - Sole methi	19.87	26.20	27.93
T_8 - Onion + methi (one row)	19.18	25.73	26.87
T_9 - Onion + methi (two rows)	18.25	22.73	22.93
T_{10} - Onion + methi (Broad cast)	17.33	21.33	21.50
SEm±	0.25	0.35	0.38
CD(P=0.05)	0.88	1.20	1.30

The data pertaining to plant height of methi continued to increase with advancement of crop age. The plant height of methi ranged from 17.33 cm in onion + methi (Broadcast) at first harvesting to 27.93 cm in methi sole crop at third harvesting. The plant height in intercropping system decreased gradually with increase in number of rows of methi. The plant height significantly varied among various intercropping system at first, second and third harvesting. Within the intercropping system, the maximum plant height was obtained from onion + methi one row at all stages of harvest, which was at par with sole crop. The lowest plant height was obtained from onion + methi broadcasting(17.33 at 1st, 21.33 at 2nd and 21.50 at 3rd harvesting) followed by intercropping of onion+ methi (two rows).

4.3.2. Number of branches at each harvest of methi

The data on number of branches of methi recorded at different harvesting as influenced by sole cropping and different intercropping are summarized in table 4.13.

Table 4.13 Effect of different onion + methi intercropping combinations on number of branches of methi at different harvesting

Treatments	Number of branches Plant^{-1} of methi		
	1st harvesting	2nd harvesting	3rd harvesting
T_3 - Sole methi	2.54	2.68	5.13
T_8 - Onion + methi (one row)	2.46	2.52	3.60
T_9 - Onion + methi (two rows)	2.28	2.38	3.13
T_{10} - Onion + methi (Broad cast)	2.16	2.24	2.87
SEm±	0.03	0.04	0.06
CD (P=0.05)	0.11	0.12	0.20

The number of branches of methi was significantly affected by various intercropping treatments at first, second and third harvesting. The data indicated that number of branches plant^{-1} of methi continued to increase with advancement ranged from 2.16 in onion + methi broadcast at first harvesting to 5.13 in methi sole crop at third harvesting. The number of branches plant^{-1} in intercropping system decreased gradually with the increase number of rows of methi in between onion plants. The number of branches significantly varied among various intercropping system at first, second and third harvesting. Within the intercropping system, the maximum branches (2.46 at 1st, 2.52 at 2nd & 3.60 at 3rd harvesting) were obtained from onion+ methi (one row), which was significantly higher than onion + methi (two rows) (2.28 at 1st, 2.38 at 2nd & 3.13 at 3rd harvesting) and onion + methi (broadcasting) (2.16 at 1st, 2.24 at 2nd & 2.87 at 3rd harvesting). The lowest number of branches was obtained from onion + methi (broadcasting).

4.3.3. Leaf yield of methi at different harvest and total yield (q ha^{-1})

Table 4.14 Effect of different onion + methi intercropping combinations on leaf yield of methi (q ha^{-1}) at different harvesting

Treatments	Leaf yield of methi (q ha^{-1})			
	1st harvesting	2nd harvesting	3rd harvesting	Total yield
T_3 - Sole methi	36.48	40.80	45.41	122.69
T_8 - Onion + methi (one row)	29.72	34.36	41.36	105.44
T_9 - Onion + methi (two rows)	30.36	35.72	42.38	108.46
T_{10} - Onion + methi (Broad cast)	27.58	32.58	39.03	99.19
SEm±	0.43	0.49	0.60	1.55
CD(P=0.05)	1.48	1.70	2.08	5.37

The perusal of data revealed that yield of methi continued to increase with advancement of crop age. The yield of methi ranged from 27.58 q ha^{-1} in onion + methi (broadcast) at first harvesting to 45.41 q ha^{-1} in methi sole crop at third harvesting. The yield of methi in intercropping system increased gradually with the increase in number of rows of methi. The yield of methi significantly differed among various intercropping combinations at first, second and third harvesting. Within the treatments of intercropping the maximum yield of methi (108.46 q ha^{-1}) was recorded from onion + methi (two rows), which was at par with onion + methi (one row) (105.44 q ha^{-1}). The lowest yield of methi was obtained from onion + methi (broadcast). Similarly, the total yield of methi was obtained maximum for sole methi (122.69 q ha^{-1}) and onion + methi (two rows) *i.e.* 108.46 q ha^{-1} among different intercropping system and lowest yield of methi (99.19 q ha^{-1}) was recorded from onion + methi (broadcast) treatment.

4.4. Onion equivalent yield

The data presented in Table 4.15 clearly indicated that all the intercropping treatments showed higher value for equivalent yield of onion over the sole cropping except onion+ palak (broadcast) and onion+ methi (broadcast).

Table-4.15: Onion equivalent yield (q/ha)) of *onion+ palak and onion+ methi* intercropping system

Treatments	Onion seed equivalent yield (q/ha)
T_1 - Onion seed crop (Sole crop)	6.16
T_4 - Onion + Palak (One row)	6.54
T_5 - Onion + Palak (Two rows	6.35
T_6 - Onion + Palak (Three rows)	6.36
T_7 - Onion + Palak (Broad-cast)	6.06
T_8 - Onion + Methi (One row)	6.50
T_9 - Onion + Methi (Two rows)	6.30
T_{10} - Onion + Methi (Broadcast)	6.01
SEm±	0.04
CD (P = 0.05)	0.11

Onion + Palak (One row) and Onion + Methi (One row) intercropping were statistically at par but gave significantly higher onion equivalent yield (6.54 and 6.50 qha^{-1}, respectively) as compared to all other treatments. Onion equivalent yield in onion

intercropping with one row of palak and methi registered 6.17 and 5.52 per cent higher yield, respectively over sole seed crop of onion. Different row ratios of Onion + Palak registered higher onion equivalent yield as compared to Onion + methi system.

4.5. Economic analysis of intercropping

The economic feasibility of different agronomic practices is usually a deciding factor for its adoption by the farmers for commercialization of any crop production programme. It is, therefore, of common interest to calculate the effect of different planting methods of intercropping in seed onion taken in this study.

Economic efficiency of various treatments taken in this study was worked out on the basis of net return. The prevailing market rates remained during field experimentation at CCS Haryana Agricultural University, Hisar were taken in to account for this purpose. Data obtained were summarized in Table- 4.16.

Table 4.16: Economics and benefit cost ratio of Onion + *palak and onion + methi* intercropping system

Treatments	Gross return (Rs. /ha.)	Total Cost (Rs. /ha.)	Net return (Rs. /ha.)	B:C Ratio
T_1 - Onion seed crop (Sole crop)	616000	104281	511719	4.91
T_2 – Palak (Sole crop)	91600	34941	56660	1.62
T_3 – Methi (Sole crop)	85883	33750	52134	1.54
T_4 - Onion + Palak (One row)	654056	105881	548175	5.18
T_5 - Onion + Palak (Two rows	634632	107281	527351	4.92
T_6 - Onion + Palak (Three rows)	636744	108281	528463	4.88
T_7 - Onion + Palak (Broad-cast)	606136	108681	497455	4.58
T_8 - Onion + Methi (One row)	649808	105561	544247	5.16
T_9 - Onion + Methi (Two rows)	629922	107481	522441	4.86
T_{10} - Onion + Methi (Broadcast)	601433	107801	493632	4.58

Sale price of onion seed @ Rs. 1000/kg, Palak @ Rs.8/kg and Methi @7/kg

A perusal of data presented in Table-4.16 reveals that there was considerable impact of various treatments on economics of the factors under study in relation to the other effects on yield and expenditure involved in intercropping of onion+ palak and onion + methi. Maximum net return (Rs 548175/ha) and B:C ratio (5.18) was recorded for onion+ *palak (one row)* closely followed by onion+ *methi (one row)* gave Rs. 544247/ha and 5.16 net return and B: C ratio, respectively and onion+ *palak (two rows)* (Rs 527351/ha and 4.92 net return and B: C ratio respectively).

It was also found that all the intercropping treatments were more remunerative than sole cropping (Rs 511719/ha and 4.91 net return and B: C ratio respectively). Sole cropping of *methi* recorded minimum values for net return per hectare and B: C ratio (Rs 52134 and 1.54, respectively) followed by sole *palak* gave net return and B:C ratio (Rs.56660/ha and 1.62, respectively).

CHAPTER -V

DISCUSSION

The results of present study entitled *'Evaluation of intercrop and their pattern in onion seed crop'* described in the previous chapter reveal that the parameters recorded for onion, palak and methi crops were influenced by different treatments of intercropping combinations. The performance of a cropping system is mainly determined by the efficiency of a system in which the basic resources are used in optimum manner. This depends on not only efficiency of individual component crop of the system but also on how well the crops complimented each other in time and space. In this chapter, an attempt has been made to assign reasons responsible for variation that occurred due to different treatments. The results are discussed and explained in the light of information obtained by other workers in intercropping system of various vegetable crops.

5.1. Growth and phonological parameters of onion as main crop

The plant height was significantly influenced by various intercropping treatments at first, second and third harvesting. Sole onion crop produced significantly taller plants (29.84 at 1st, 78.60 at 2nd & 84.45 at 3rd harvesting) than rest treatments of intercrops (Table 4.2). Plant height was recorded with onion + palak and onion + methi (one row), which was significantly higher than rest treatments of intercrops. This might be due to more competition among the plants for nutrients, moisture, light and space in onion sole crop and with single row of palak and methi than other treatments.

The number of seed stalks bulb^{-1}, length of flower stalk and diameter of flower stalk have been summarized in table 4.4. The data expressed that number of seed stalk bulb^{-1} was significantly decreased with increase in palak and methi population than sole crop of onion. Onion + palak (one row) produced significantly higher number of seed stalks bulb^{-1} than rest of the treatments. Onion + palak (broadcasting) and onion + methi (broadcasting) had lower number of seed stalks bulb^{-1}. Onion + palak (one row) was at par with onion + methi (one row) and onion + palak (two rows), but produce significantly higher length of flowers stalks and diameters of flowers stalk than rest of the treatments. The lowest values of these characters were recorded with onion + palak (broadcasting) and onion + methi (broadcasting). The number of seeds umbel^{-1} and seed weight umbel^{-1} exhibited decreasing trends with the increase in number of palak and methi rows as intercrop. The maximum number of seeds umbel^{-1} and seed weight umbel^{-1} was found in treatments onion seed crop (sole) as compared to other treatments.

Onion seed crop (sole) produced significantly higher number and weight of seeds plant^{-1} than rest of the treatments. The increased number and weight of seed plant^{-1} might be

attributed to enhanced photosynthetic activity in sole crop, due to more space and less competition for nutrients which resulted in more and accumulation of carbohydrates, increased production favourable effect on vegetative growth and retention of flowers which might have increased the number and weight of seeds plant^{-1}. The reduction in number and weight of seed plant^{-1} under intercropping treatments might be due to mutual competition among both the crops. Decreased number of seed in response to increase plant population has been reported by Paul *et al.* (2015) and Islam *et al.* (2016) in brinjal. In intercropping system, onion + palak (one) row was at par with onion + methi (one row) and both the treatments increased appreciably higher number and weight of seeds plant^{-1} as compared to other treatments of intercropping.

5.2. Seed yield

Seed yield of onion decreased significantly due to palak and methi intercrops when compared with onion sole crop, which might be due to on account of higher plant population in intercropping treatments as compared to sole crop. The maximum seed yield (6.16 q ha^{-1}) was register with onion sole crop at spacing 60×60 cm and minimum (5.32 q ha^{-1}) was recorded with onion + methi (broadcasting). Among the different intercropping treatments onion + palak (one row) gave the maximum seed yield (5.78 q ha^{-1}), which was at par (5.76 q ha^{-1}) with onion + methi (one row) but both the treatments resulted in significantly higher seed yield when compared with rest treatments of intercropping. The higher seed yield in above treatments might be attributed to more number and weight of seeds plant^{-1}. As the onion equivalent yield is concerned, Onion + Palak (One row) and Onion + Methi (One row) intercropping gave significantly higher onion equivalent yield as compared to all other intercropping and sole crop treatments. The results of present experiment are in close conformity with the results of Obadoni *et al*. (2005), Suresha *et. al.* (2007) and Islam *et. al.* (2016) while working with brinjal, tomato and chili intercropping system, respectively.

Rodge and Yodlod (2009) studied the intercropping in different vegetable and they found palak have better companion effect over radish, onion and coriander in the field of brinjal taken as intercrop. The percent decrease in seed yield of onion (table 4.7) due to palak and methi intercropping in various treatments ranged in between 6.17 to 13.14 per cent and 6.49 to 13.64 per cent, respectively. This might be due to competition on onion from intercrops, leading to reduced seed yield plant^{-1} and reflected in total seed yield. Singh and Kushwah (2012) reported that intercropping of radish or spinach with potato reduced potato yield by 17 per cent and 8 per cent, respectively. The fruit yield reduction of brinjal in intercropping combinations was 2.02 to 5.98 per cent as compared to sole crop (Islam *et al.* 2016).

5.3. Growth and phonological parameters of palak and methi as intercrops.

The leaf attributes such as, leaf length, petiole length and leaf width were found significantly better in treatment palak sole crop as compared to intercrop (Table 4.8,4.9 and 4.10).

It found that leaf characters continued to increase with the advancement in crop age due to availability of more favourable environmental conditions of palak crop production as the temperature was high at initial stage of growth. Gaharwar (2014) mentioned that length of leaf, petiole and diameter of leaf increased with the increase in number of cuttings. Among the treatments of intercropping, the maximum value of these attributes was obtained from onion + palak (one row) treatment as this treatment involves minimum plant population comparative to other treatments, which lead to minimum reduction for these attributes. Similar results were found by Islam *et al.* (2016) for garlic crop when intercropped with brinjal.

Onion + palak (three rows) and onion + palak (broad casting) recorded minimum value for these attributes and found non-significant. This might be due to more competition and shading effect from main crop and thereby has to lead to lowest use and poor availability of all the available resources by palak and produced lower biomass. These results of present experiment are in concurrence with observation of Paul *et al.* (2015) where he found the growth and yield attributes of coriander were suppressed by main crop of brinjal.

5.4. Leaf yield of palak and methi

The yield of palak and methi leaves continued to increase with the advancement of crop age due to availability of favourable environmental conditions in the growing seasons, an early season, there was high temperature and longer days, which are unfavorable for the growth of palak. Gaharwar (2014) also reported that the leaf yield continued increase with increase in number of cutting.

The leaf yield was significantly superior with treatment palak (sole crop) (Table 4.11) among various intercropping treatments at first, second and third harvesting. Leaf yield decreased appreciably due to the competition among the crops, lands for moisture, nutrients, space and light. These findings confirm with the results of Abd el-gaic *et al.* (2014) regarding the bean yield in tomato-bean intercropping system. Within the intercropping treatments, the maximum leaf yield was obtained from onion + palak (three rows), which was at par with sole palak and minimum leaf yield was observed in onion + palak (broad casting). Paul *et al.* (2015) also reported the similar findings in brinjal- coriander intercropping system.

The per cent decrease in total leaf yield of palak during first three harvesting might be due to decreased plant population of palak and competitive and shading effect of main crop among various treatments ranged in between 16.64 to 22.03 per cent. The maximum decrease in leaf yield was observed in treatment onion + palak (broadcasting), followed by onion + palak (one row) and onion + palak (two rows). The minimum decrease in leaf yield was observed in onion + palak (three rows). These results corroborate the findings of Ahmed *et al.* (2013) in okra and Islam *et al.* (2016) in brinjal intercropping system. Almost similar trends were recorded in growth attributes and yield of methi as obtained with palak crop.

5.5. Onion Seed equivalent Yield

The maximum value of onion seed equivalent yield was recorded in onion + palak one row intercropping system . The increase in yield of onion seed might be attributed due to the increase in growth attributes, number of umbels per plant and number of seeds per umbel, as the main crop onion was slow growing and *palak* and methi as intercrop were fast growing with higher price received in the market to give substantial yield advantage. Similar findings were reported by Singh *et al.* (2016) in potato based intercropping.

5.6. Economics of production

Among different combinations, onion + *palak* one row intercropping system was found most remunerative with maximum net return and benefit to cost ratio followed by onion + *methi* one row. This might be due to higher onion and palak yield. *Methi* grown alone was least remunerative than all other treatments with minimum values for net return and benefit to cost ratio followed by *Palak* sole crop. These results are inconformity with the findings of Sujay and Giraddi (2015) who obtained highest net return and benefit cost ratio from chilli intercropped with onion. Similar results were recorded by Kumar *et al*. (2005) and Kumar *et al.* (2014) in maize cowpea intercropping system and okra based intercropping system.

CHAPTER -VI

SUMMARY AND CONCLUSION

The present experiment was conducted at Research Farm of the department of Vegetable Science, CCS Haryana Agricultural University, Hisar (Haryana) during *rabi* season of 2018 - 19 in order to investigate the effect on intercropping on growth yield of onion seed crop, palak and methi. The experimental treatments were laid out in Randomized Block Design with the three replications. The data on vegetative growth, seed yield of onion and leaf yield of palak and methi were collected from five randomly selected competitive plants from each unit plot. The collected data were analyzed statistically and the mean differences were evaluated by least significant differences (LSD) test at 5% level of significance. The results of the experiment show that the intercropping had significant and positive influence on most of the characters. Significant effects of intercropping were observed on parameters such as plant height (cm), number of seed stalks bulb^{-1}, length of flower stalks (cm), diameter of flower stalk (cm), number and weight of seed plant^{-1} (g), seed yield (q ha^{-1}) and test weight of onion seed and leaf length (cm), petiole length (cm), leaf width (cm) and leaf yield of palak (q ha^{-1}) and plant height (cm) and number of branches plant^{-1} and leaf yield of methi (q ha^{-1}). The salient findings of the investigation are summarized in this chapter as follows.

6.1. Growth and yield parameters of onion (main crop)

1. Plant height, number of seed stalks bulb^{-1}, length and diameter of flower stalks, number and weight of seeds umbel^{-1} and plant^{-1} were significantly higher in onion sole crop of onion than rest of the treatments.
2. With the increase in number of rows in intercrops, the growth and yield attributes of onion decreased irrespective of the treatments due to competition of nutrients and space.
3. Within the intercropping system, the maximum plant height was obtained in onion + palak (one row) combination.
4. The yield attributes such as number and weight of seed umbel^{-1} and seeds plant^{-1} were significantly higher in onion sole crop at spacing of 60×60 cm.
5. In intercropping system, the number and weight of seed umbel^{-1} were appreciably higher in onion + methi (one row) followed by onion + palak (one row). Whereas, the seed yield plant^{-1} significantly improved in onion + palak (one row) followed by onion + methi (one row).
6. The seed yield of onion was recorded maximum in onion sole crop, which was significantly higher than rest of the treatments. With the increase in number of rows of

palak one to three and methi one to two, there was significant reduction in seed yield of onion crop.

7. Onion equivalent yield was significantly higher in case of Onion + Palak (One row) and Onion + Methi (One row) intercropping as compared to all other treatments of intercropping and sole crop.

6.2 Growth and yield parameters of palak and methi (intercrop)

1. Palak sole crop had significantly higher leaf length and petiole length than intercropping treatments. Whereas, leaf width did not influence significantly.
2. In Intercropping combination, onion + palak (one row) gave significantly higher leaf length than onion + palak (two and three rows), and onion + palak (broadcasting).
3. Palak sole crop in intercropping was at par with onion + palak one, two and three rows, but they significantly superior to onion + palak broadcasting.
4. The leaf yield of palak was significantly higher with palak sole crop than intercropping treatments.
5. Methi sole crop was at par with onion + methi (one row) but both the treatments produced longer plants than onion + methi (two rows) and broadcasting.
6. The maximum number of branches plant^{-1} of methi was recorded with methi sole crop which were significantly higher than onion + methi one and two rows and broadcasting.
7. Methi sole crop produced significantly higher leaf yield of methi than intercropping treatments.

6.3 Onion Seed Equivalent Yield (OEY)

The maximum onion seed equivalent yield was obtained in the intercropping system of onion + palak (one row).

6.4 Economics of production

All the intercropping treatments were proved more economical as compared to sole crop of onion, *palak* and *methi*. Among different combinations, onion + *palak* one row intercropping system was found most remunerative with maximum net return and benefit cost ratio followed by onion + *methi* one row.

Conclusion

From the present study, it has been concluded that onion seed crop intercropped with one row of *palak* or one row of methi could be more remunerative for earning maximum net returns of Rs.548175/ha for onion + palak (one row) and Rs.544247/ha for onion + methi (one row) than the seed onion sole crop (Rs.511719/ha) because of higher yield due to less competition for nutrients and space.

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APPENDIX I

Analysis of variance for Days to 50% sprouting of bulbs

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.409248	0.204624	0.87	3.74
Treatments	7	2.189712	0.312816	1.33	2.7
Error	14	3.2928	0.2352		
Total	23	5.89176			

APPENDIX II

Analysis of variance for plant height of onion (1st harvesting)

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.51714	0.25857	1.02	3.74
Treatments	7	6.122025	0.874575	3.45	2.7
Error	14	3.549	0.2535		
Total	23	10.18817			

Analysis of variance for plant height of onion (2nd harvesting)

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	4.12337	2.061685	1.13	3.74
Treatments	7	45.46654	6.49522	3.56	2.7
Error	14	25.543	1.8245		
Total	23	75.13291			

Analysis of variance for plant height of onion (3rd harvesting)

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	5.270496	2.635248	1.24	3.74
Treatments	7	54.44762	7.778232	3.66	2.7
Error	14	29.7528	2.1252		
Total	23	89.47092			

APPENDIX III

Analysis of variance for Days to 50% flowering

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.640332	0.320166	0.98	3.74
Treatments	7	4.276503	0.610929	1.87	2.7
Error	14	4.5738	0.3267		
Total	23	9.490635			

APPENDIX IV

Analysis of variance for Number of seed stalk bulb^{-1}

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.056068	0.028034	1.07	3.74
Treatments	7	0.601552	0.085936	3.28	2.7
Error	14	0.3668	0.0262		
Total	23	1.02442			

Analysis of variance for Length of flower stalk

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	6.335436	3.167718	1.11	3.74
Treatments	7	70.71716	10.10245	3.54	2.7
Error	14	39.9532	2.8538		
Total	23	117.0058			

Analysis of variance for diameter of flower stalk

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.006272	0.003136	2.24	3.74
Treatments	7	0.063994	0.009142	6.53	2.7
Error	14	0.0196	0.0014		
Total	23	0.089866			

APPENDIX V

Analysis of variance for number of seed umbel^{-1}

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	619.1109	309.5555	0.96	3.74
Treatments	7	8328.976	1189.854	3.69	2.7
Error	14	4514.35	322.4536		
Total	23	13462.44			

Analysis of variance for seed weight umbel^{-1}

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.01665	0.008325	1.85	3.74
Treatments	7	0.185441	0.026492	5.887	2.7
Error	14	0.063	0.0045		
Total	23	0.265091			

APPENDIX VI

Analysis of variance for Number of seeds plant^{-1}

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	25603.31	12801.65	0.86	3.74
Treatments	7	311556.5	44508.07	2.99	2.7
Error	14	208399	14885.64		
Total	23	545558.8			

Analysis of variance for seed weight plant^{-1} (g)

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.60724	0.30362	1.88	3.74
Treatments	7	4.126325	0.589475	3.65	2.7
Error	14	2.261	0.1615		
Total	23	6.994565			

APPENDIX VII

Analysis of variance for seed yield (qha^{-1})

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.035084	0.017542	1.79	3.74
Treatments	7	0.574868	0.082124	8.38	2.7
Error	14	0.1372	0.0098		
Total	23	0.747152			

Analysis of variance for test weight(g)

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.01674	0.00837	1.86	3.74
Treatments	7	0.067095	0.009585	2.13	2.7
Error	14	0.063	0.0045		
Total	23	0.146835			

APPENDIX VIII

Analysis of variance for Leaf length of palak at 1st harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.163584	0.081792	1.44	4.46
Treatments	4	0.92016	0.23004	4.05	3.84
Error	8	0.4544	0.0568		
Total	14	1.538144			

Analysis of variance for Leaf length of palak at 2nd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.19668	0.09834	1.32	4.46
Treatments	4	1.30524	0.32631	4.38	3.84
Error	8	0.596	0.0745		
Total	14	2.09792			

Analysis of variance for Leaf length of palak at 3rd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.26634	0.13317	1.38	4.46
Treatments	4	1.70612	0.42653	4.42	3.84
Error	8	0.772	0.0965		
Total	14	2.74446			

APPENDIX IX

Analysis of variance for petiole length of palak at 1st harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.128904	0.064452	1.23	4.46
Treatments	4	0.855168	0.213792	4.08	3.84
Error	8	0.4192	0.0524		
Total	14	1.403272			

Analysis of variance for petiole length of palak at 2nd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.152944	0.076472	1.21	4.46
Treatments	4	1.059232	0.264808	4.19	3.84
Error	8	0.5056	0.0632		
Total	14	1.717776			

Analysis of variance for petiole length of palak at 3rd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.2178	0.1089	1.32	4.46
Treatments	4	1.3926	0.34815	4.22	3.84
Error	8	0.66	0.0825		
Total	14	2.2704			

APPENDIX X

Analysis of variance for Leaf width of palak at 1st harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.062712	0.031356	1.34	4.46
Treatments	4	0.292032	0.073008	3.12	3.84
Error	8	0.1872	0.0234		
Total	14	0.541944			

Analysis of variance for Leaf width of palak at 2nd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.076608	0.038304	1.14	4.46
Treatments	4	0.413952	0.103488	3.08	3.84
Error	8	0.2688	0.0336		
Total	14	0.75936			

Analysis of variance for Leaf width of palak at 3rd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.091476	0.045738	1.21	4.46
Treatments	4	0.474768	0.118692	3.14	3.84
Error	8	0.3024	0.0378		
Total	14	0.868644			

APPENDIX XI

Analysis of variance for Leaf yield of palak (qha^{-1}) at 1st harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	0.5203	0.26015	1.10	4.46
Treatments	4	4.31376	1.07844	4.56	3.84
Error	8	1.892	0.2365		
Total	14	6.72606			

Analysis of variance for Leaf yield of palak (qha^{-1}) at 2nd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	1.218684	0.609342	1.23	4.46
Treatments	4	9.273888	2.318472	4.68	3.84
Error	8	3.9632	0.4954		
Total	14	14.45577			

Analysis of variance for Leaf yield of palak (qha^{-1}) at 3rd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	2.196084	1.098042	1.27	4.46
Treatments	4	16.53115	4.132788	4.78	3.84
Error	8	6.9168	0.8646		
Total	14	25.64404			

Analysis of variance for Total Leaf yield of palak (qha^{-1})

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	11.94706	5.973528	1.32	4.46
Treatments	4	82.5433	20.63582	4.56	3.84
Error	8	36.2032	4.5254		
Total	14	130.6936			

APPENDIX XII

Analysis of variance for plant height of methi at 1st harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	20.90735	10.45367	2.31	5.14
Treatments	3	67.74524	22.58175	4.99	4.76
Error	6	0.7692	0.1282		
Total	11	89.42179			

Analysis of variance for plant height of methi at 2nd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	21.4504	10.7252	2.37	5.14
Treatments	3	71.41081	23.8036	5.26	4.76
Error	6	1.4508	0.2418		
Total	11	94.31201			

Analysis of variance for plant height of methi at 3rd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	21.08836	10.54418	2.33	5.14
Treatments	3	73.71877	24.57292	5.43	4.76
Error	6	1.587	0.2645		
Total	11	96.39413			

APPENDIX XIII

Analysis of variance for no. of branches of methi at 1st harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	22.98903	11.49452	2.54	5.14
Treatments	3	79.55653	26.51884	5.86	4.76
Error	6	0.0126	0.0021		
Total	11	102.5582			

Analysis of variance for no. of branches of methi at 2nd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	22.26497	11.13248	2.46	5.14
Treatments	3	76.84129	25.61376	5.66	4.76
Error	6	0.0156	0.0026		
Total	11	99.12186			

Analysis of variance for no. of branches of methi at 3rd harvesting

Source	df	SS	MSS	F-Cal	F-Tab
Replication	2	22.89852	11.44926	2.53	5.14
Treatments	3	77.11282	25.70427	5.68	4.76
Error	6	0.0384	0.0064		
Total	11	100.0497			

APPENDIX XIV

Analysis of variance for leaf yield of methi(qha^{-1}) at 1st harvesting

Source	Df	SS	MSS	F-Cal	F-Tab
Replication	2	23.7131	11.85655	2.62	5.14
Treatments	3	79.01348	26.33783	5.82	4.76
Error	6	2.1888	0.3648		
Total	11	104.9154			

Analysis of variance for leaf yield of methi(qha^{-1}) at 2nd harvesting

Source	Df	SS	MSS	F-Cal	F-Tab
Replication	2	23.89411	11.94706	2.64	5.14
Treatments	3	79.82806	26.60935	5.88	4.76
Error	6	2.895	0.4825		
Total	11	106.6172			

Analysis of variance for leaf yield of methi (qha^{-1}) at 3rd harvesting

Source	Df	SS	MSS	F-Cal	F-Tab
Replication	2	24.07513	12.03756	2.66	5.14
Treatments	3	79.96382	26.65461	5.89	4.76
Error	6	4.3296	0.7216		
Total	11	108.3685			

Analysis of variance for total yield of methi (qha^{-1})

Source	Df	SS	MSS	F-Cal	F-Tab
Replication	2	24.16564	12.08282	2.67	5.14
Treatments	3	80.91415	26.97138	5.96	4.76
Error	6	28.9524	4.8254		
Total	11	134.0322			

APPENDIX XV

Analysis of variance for equivalent yield of onion (qha^{-1})

Source	Df	SS	MSS	F-Cal	F-Tab
Replication	2	0.927828	0.463914	1.42	3.74
Treatments	7	10.474	1.496286	4.58	2.7
Error	14	4.5738	0.3267		
Total	23	15.97563			

ABSTRACT

Title of Thesis	:	**Evaluation of intercrop and their pattern in onion seed crop**
Name of Degree holder	:	**Nitesh Kumar**
Admission number	:	2017A75M
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Year of award of Degree	:	2021
Major Subject	:	Vegetable Science
Total number of pages in thesis	:	35 + iv + VII
Number of words in abstract	:	281

Keyword: Evaluation of intercrop, Onion Equivalent, Randomized Block Design, Plant height

The present investigation entitled "Evaluation of intercrop and their pattern in onion seed crop" was carried out at Research Farm of the Department of Vegetable Science, CCS Haryana Agricultural University, Hisar during season of 2018-19. The experimental treatments *viz*., T_1-onion seed crop (sole) 60 X 60 cm , T_2-*palak* (sole) 15 X 5cm, T_3-methi (sole) 20 X 10 cm , T_4-onion + *palak* (one row) T_5- onion + *palak* (two rows), T_6- onion + *palak* (three rows), T_7- onion + *palak* (broadcasting), T_8- onion + *methi* (one row), T_9- onion + *methi* (two rows) and T_{10}- onion + *methi* (broadcasting) were laid out in a Randomized Block Design (RBD) with three replications. Based on the research investigation it was found that the Plant height, number of seed stalks bulb^{-1}, length and diameter of flower stalks, number and weight of seeds umbel^{-1} and plant^{-1} were significantly higher in sole crop of onion than rest of the treatments. Sole crop of onion at spacing 60 X60 cm provided the maximum yield of seed per unit area. The leaf yield of palak was significantly higher with palak sole crop than intercropping treatments due to minimum competition between the plants for space and nutrients. Maximum net return (Rs 548175/ha) and B:C ratio (5.18) was recorded for onion+ *palak (one row)* after that treatment of onion+ *methi (one row)* gave a following net return of Rs. 544247/ha and B: C ratio of 5..16 Also onion + *palak* (one row) intercropping system gave highest onion seed equivalent yield (OEY) *i.e*.6.54 q/ha. It has been concluded that onion intercropped with *palak* (one row)could be more remunerative for earning maximum net returns than the onion sole crop.

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