Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; SP1: 3274-3279

Dr. Dinesh Sharma
Department of Vegetable Science, COA, CCS Haryana Agricultural University, Hisar, Haryana, India

Dr. B Rai Batra
Department of Vegetable Science, COA, CCS Haryana Agricultural University, Hisar, Haryana, India

Correspondence
Dr. Dinesh Sharma
Department of Vegetable Science, COA, CCS Haryana Agricultural University, Hisar, Haryana, India

Effect of irrigation and fertility levels on phenology, partitioning of biomass, yield and quality of radish (*Raphanus sativus* L.) seed crop

Dr. Dinesh Sharma and Dr. B Rai Batra

Abstract
An investigation entitled, "Effect of irrigation and fertility levels on phenology, partitioning of biomass, yield and quality of radish (*Raphanus sativus* L.) seed crop", was carried out at Vegetable Research area of CCS Haryana Agricultural University, Hisar during winter seasons of 2001-02 and 2002-03. The experiment was laid out in split-plot design with three replications. The main plot treatments comprised three irrigation levels viz., i) ID/CPE 0.4, ii) ID/CPE 0.6 and iii) ID/CPE 0.8. The sub-plot treatments consisted of three fertility levels [25% < recommended, as recommended (80kg N + 40kg P_2O_5 & K_2O each/ha), 25% > recommended and 50% > recommended]. The plant growth in terms of plant height, number of branches, LAI, LAD, CGR, dry matter accumulation and its partition to different plant parts were positively influenced by the increasing levels of irrigation and fertility during both the years. The different characters (days to flowering in 50% plant, partitioning of dry matter in various parts at 30 DAP and seed vigor index) did not show any marked response to irrigation levels during both the years. The maximum seed yield and significant increase in yield attributing parameters were recorded in plants subjected to ID/CPE 0.8 irrigation level and 25%> recommended fertility level which however, did not differ significantly with 50%> recommended. The NPK contents in plant parts and seed increased with increase in intensity of irrigation & fertility supply. The consumptive use of water also increased but water use efficiency decreased with increasing level of irrigation.
On the basis of the findings obtained from two years study, it can be concluded that the highest seed yield with better partitioning of biomass could be insured with highest intensity of irrigation (ID/CPE 0.8) in conjunction with 25%> recommended fertility level.

Keywords: Radish, NPK, Biomass, Dry Matter, Irrigation

Introduction
Radish (*Raphanus sativus* L.), one of the important root vegetable extensively cultivated during winter season through out the world. It is also called 'Mooli' is an annual or biennial herb has a rosette of leaves vary in size. The edible portion of radish root develops from both primary root & the hypocotyls. It is a cross-pollinated vegetable due to sporophytic system of self-incompatibility and mode of pollination is entomophilous and shows considerable inbreeding depression upon selfing. It is native of central western China and belongs to family cruciferae (2n=18). Being a short duration crop it is best suited to grow as intercrop and catch crop. Radish is of two types namely, Asiatic and European types. Asiatic types are annuals, requiring less chilling temperature and their seed can be freely produced in plains, whereas European types biennial in nature & require chilling temperature of 0-4ºC for a period of 450-500 hours for seed setting.
The productivity of the root crop is influence by quality of seed to a large extent. In order to exploit the quality seed yield potential of an improved cv. manipulation of certain agronomical practices in general but agro-techniques for irrigation in combination with fertility levels in specific is very essential and important.
Phenological studies of the crop give us understanding of the growth and development of various plant parts, which in turn effect the seed yield & quality, hence, importance of phenological studies is immense in multiple cropping systems. Water deficit adversely affect various morphological processes of the plant and in turn the crop productivity in a region. Partitioning of biomass is more important as the farmer's economy depends on better partitioning of sink. Understanding of physiological and phenological cause of yield reduction with reference to fertility and irrigation for improvement in seed yield and knowledge of dry matter accumulation in different plant parts at successive growth stages is also necessary to assess the nutritional requirement of plants. Very limited work has been done on the irrigation and fertility requirements for seed yield and quality of Radish Seed Crop in India.

Therefore, keeping the above facts in view, the present investigation was undertaken to develop agro-techniques for seed production of Hisar Selection-1 variety of radish under Hisar (Haryana) conditions with the following objectives:

1. To study the effect of Irrigation Levels on Phenology, Partitioning of Biomass, Yield and Quality of Radish Seed Crop
2. To evaluate the effect of Fertility Levels on Phenology, Partitioning of Biomass, Yield and Quality of Radish Seed Crop
3. To work out the Better Combination of Irrigation and Fertility for Yield and Quality of Radish Seed Crop

Material and Methods

The field experiment entitled "Effect of Irrigation and Fertility Levels on Phenology, Partitioning of Biomass, Yield and Quality of Radish (*Raphanus sativus* L.) Seed Crop", in respect of cv. Hisar Selection -1 was conducted at Vegetable Research Farm of CCS Haryana Agricultural University, Hisar during winter season of 2001-02 & 2002-03. In this chapter the details of the materials used and techniques followed to carry out the experiment are described.

Experimental Site

Hisar is situated in the sub-tropical climatic zone at 29^0-10^I North latitude and 75^0-46^I East longitudes with an altitude of 215.2 meters above mean sea level.

Weather and climatic conditions

The climate of Hisar region is semi-arid and is characterized by hot and dry winds with dust storm during summer months and dry & severe cold conditions with fog & frost during winter and humid warm monsoon months. The mean maximum and minimum temperature shows wide range of fluctuation during summer while the temperature below freezing point accompanied by frost may be recorded during winter (Dec-Jan), which is not in common in this region. The average annual rainfall in this region is around 400mm. Most of which rainfall (South-West) is confined mainly to the monsoon months from July- September with a few cyclonic showers during winter and spring season. The means morning relative humidity remain nearly constant at above 80% from July to end of March, then it steady decrease of about 40% by the end of April & remain so till June.

Soil

The result of soil test indicates that the soil of experimental field was sandy loam in texture. The pH of the field was 7.8 to 8.1, thus indicating alkaline nature of the soil. The soil was rich in P & K, medium in original carbon & poor in N.

The soil samples were collected from 5 different sites of the experimental field and mixed well to make a representative sample for analysis of soil, the composite soil sample were taken from 0-30, 30-60, 60-90 cm depth on the basis of average of two years to determine mechanical and physical analysis of soil. For chemical analysis, the soil sample were taken from 0-15, 15-30 cm depth.

Experimental Details

Treatments:

The experiment was planned & executed to study the "Effect of Irrigation and Fertility Levels on Phenology, Partitioning of Biomass, Yield and Quality of Radish (*Raphanus sativus* L.) Seed Crop" in cv. Hisar Selection-1 developed by the department of Vegetable Science, CCS Haryana Agricultural University, Hisar. To evaluate the effect of different irrigation & fertility levels on phenology, biomass partitioning, yield & quality of seed, the experiment was laid out in split-plot design consisting of 36 treatments comprising of three irrigation levels, four fertility levels replicated thrice.

1. Main plot treatments - Irrigation levels=3

Irrigation levels

I_1 = ID/CPE ratio = 0.4

I_2 = ID/CPE ratio = 0.6

I_3 = ID/CPE ratio = 0.8

Irrigation was scheduled on the basis of the ratio of the depth of irrigation and cumulative pan evaporation corresponding to the value of:

I_1 = 5cm water after 125 mm cumulative pan evaporation from USWB class A Open Pan Evaporimeter, i.e., ID/CPE ratio of 0.4

I_2 = 5cm water after 82.2 mm cumulative pan evaporation from USWB class A Open Pan Evaporimeter, i.e., ID/CPE ratio of 0.6

I_3 = 5cm water after 62.5 mm cumulative pan evaporation from USWB class A Open Pan Evaporimeter, i.e., ID/CPE ratio of 0.8

The daily water balance was computed from pan evaporation and rainfall, as a guide for assessment of irrigation dates under different treatments.

2. Sub-plot treatments- Fertility levels=4

Fertility levels

F_1 = 25% < Recommended

F_2 = As Recommended (80kg N + 40kg P_2O_5 & K_2O each/ha)

F_3 = 25% > Recommended

F_4 = 50% > Recommended

The calculated doses of fertilizer were applied as per treatments in each plot during both the years of study. The full amount of phosphorus and potash were applied before steckling planting in the form of Single Super Phosphate and Muriate of Potash.

Layout of the experimental field:

The experiment was laid out in Split-Plot Design with irrigation levels in main plots and fertility levels in sub-plots and replicated three times. The plan of layout along with details of treatments is depicted in fig. 2.

The details of layout are given below: -

Design	=	Split-Plot
Number of Main plot treatments	=	3
Number of sub-plot treatments	=	4
Number of treatment combinations	=	12
Number of replications	=	3
Total number of plots	=	36
Gross plot size	=	3.75m x 3.0m
Spacing	=	75cm x 60cm
Variety	=	Hisar Selection-1

Raising of root crop

Seed of radish variety "Hisar Selection-1" was obtained from the Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar, and was sown on 25th October in 2001 & 27th October in 2002 for raising the roots. Recommended doses of fertilizers were applied @ 80kg N and 40kg P_2O_5 & K_2O each/ha in the form of Urea, SSP & Muriate of Potash respectively. Half nitrogen and entire phosphorus & potash were applied as basal dose & remaining

half of N was applied 25 days after sowing. Sowing was done on ridges at 45x10 cm spacing. Weeding, hoeing and irrigation were done as per recommendations. The roots were then uprooted to prepare steckling after selection preparation for planting of seed crop.

Cultural operations

1. Field preparation

The field was prepared by one pre-sowing irrigation applied ten days before sowing, repeated harrowing followed by planking to make soil well pulverized. After proper layout by dividing the field into different plots, measuring 3.75m x 3.0m having the 1m buffer in between plot and 2m wide channel including buffer also.

2. Fertilizer Management

The crop was fertilized with a basal dose of phosphorus & potash as per treatment in respective plots through Single Super Phosphate & Muriate of Potash and one-third dose of N through Urea. These fertilizers were drilled before the planting and remaining nitrogen was applied after 30 and 60 days of planting.

3. Preparation of steckling

From the previous root crop, true to type roots were selected randomly. After selection of roots, steckling (retaining 10-12cm of both roots & leaves and removing the rest portion) were prepared & was treated with Bavistin and planted as per treatment for seed crop.

4. Sowing Time

The prepared steckling planted on 15th December in 2001 & 21st December in 2002 at spacing 75 x 60cm.

5. Irrigation Management

Two common irrigation, one at planting and 2nd after 6-7 days after planting was applied & rest variable levels of irrigation were scheduled as per treatment (Table-5). As and when cumulative pan evaporation reached to the specified level, irrigation was applied. The depth was kept 5cm of each irrigation and quantity of water to be applied was measured with the help of bucket.

6. Inter-cultural Practices

Cultural practices such as weeding, hoeing & plant protection measures were adopted as & when required.

7. Harvesting and Threshing

The crops were harvested on 25th April in 2002 and 30th April in 2003 and threshed separately for different treatment for seed extraction.

Results and Discussion

The experiment entitled "Effect of irrigation and fertility levels on phenology, partitioning of biomass, yield and quality of radish (*Raphanus sativus* L.) seed crop", was carried out during winter session of 2001-02 and 2002-03 at the vegetable research farm, CCS Haryana Agricultural University, Hisar with a view to study the influence of different irrigation and fertility levels on seed yield of radish cv. Hisar Selection-1.

The experiment was laid out in split-plot design with three replications. The main plot treatments comprised three irrigation levels i.e. ID/CPE 0.4, ID/CPE 0.6 and ID/CPE 0.8. The subplot treatments had four fertility levels viz., 25%< recommended, as recommended (80kg N + 40kg P_2O_5 & K_2O each/ha), 25%> recommended and 50%> recommended. The findings of the study are summarized below.

Effect of irrigation

1. The plant height increased significantly with increase in frequency of irrigation for ID/CPE 0.4 to ID/CPE 0.6 and ID/CPE 0.8 at all the stages of observation after 30 DAP in 2001-02 and 60 DAP in 2002-03.
2. Number of branches at harvest was found significantly superior in the highest frequency (ID/CPE 0.8) when compared with lower frequencies.
3. In early stage of crop growth i.e. up to 30 days after planting in 1st year & 60 days after planting in 2nd year, the LAI, LAD and CGR were not markedly influenced by different moisture regimes but in later stages, there physiological parameter showed significant response to increase in moisture levels.
4. The days to bolting in 50% plants was found maximum (60.67 and 60.33) when irrigation scheduled at ID/CPE 0.8 and minimum with lower irrigation level (ID/CPE 0.4), whereas, there was no significant difference among irrigation levels with regards to number of days taken to flowering in 50% plants during both the years.
5. Increase in days to maturity was recorded when irrigation was applied with higher frequency (ID/CPE 0.8) and was found superior over the other lower frequency, whereas, the percent-lodging incidence was recorded minimum with irrigation scheduled at ID/CPE 0.4.
6. The dry matter accumulation in plant parts viz. leaf, stem, pod and root were more with higher irrigation frequency at all the stages of crop growth.
7. The yield attributing characters viz. number of pods per plant, number of seeds per pod and seed yield per plant were found to increase significantly with increasing levels of irrigation for ID/CPE 0.4 to ID/CPE 0.8.
8. Total seed yield was also increased significantly with increasing frequency of irrigation from ID/CPE 0.4 to ID/CPE 0.8. The maximum seed yield (5.85 and 5.57 q/ha), however, was recorded at ID/CPE 0.8.
9. N, P and K contents in the plant parts as well as in fresh seed increased significantly under increasing levels of irrigation during both the years.
10. Values of consumptive use of water by radish seed crop were 50.21, 64.74 and 83.56cm during 2001-02 and 52.43, 70.52 and 87.38cm during 2002-03 when irrigation scheduled at ID/CPE 0.4, 0.6 and 0.8 respectively.
11. Water use efficiency was maximum when irrigation scheduled at ID/CPE 0.4 and minimum was observed consistently under irrigation at ID/CPE 0.8. The water use efficiency values were 9.44, 7.66 and 6.67 kg/ha/cm water use in 2001-02 and 9.16, 7.29 and 6.69 kg/ha/cm water use in 2002-03 at ID/CPE 0.4, 0.6 and 0.8 respectively.

Effect of fertility

1. Higher levels significantly influenced the increase in periodic plant height towards the later stages during both the years.
2. The 25%> recommended fertility level was recorded the significant increase in number of branches with lower levels but non-significant with 50%> recommended in 1st year, whereas, maximum number of branches was recorded with highest fertility level.

3. LAI, LAD and CGR showed the significant increase where fertility supply was increased from 25%< recommended to 50%> recommended.
4. Phenological characters like days to bolting in 50% plant, days to flowering in 50% plant and days to maturity were found to increase with increased fertility levels, whereas, percent lodging incidence was recorded minimum under the 25% < recommended fertility level.
5. With the fertility levels, the total dry matter recorded significantly increased towards higher side up to 50%> recommended and was found at par with 25%> recommended fertility level.
6. Increase to 25%> recommended in fertility level resulted in significant increase in yield attributing characters viz. number of pods per plant, number of seeds per pod and seed yield per plant.
7. Seed yield per hectare was significantly higher when fertility was applied at 25%> recommended and 50%> recommended as compared to lower levels during both the years, however, both higher levels were at par.
8. Increasing levels of fertility significantly influenced the N, P and K contents in plant parts as well as in fresh seed.
9. Consumptive use of water, water use efficiency and soil moisture extraction pattern did not differ significantly under different fertility levels.

Several workers have studied the effect of irrigation and fertility levels on Radish Seed Crop, but literature with particular reference to phenology, partitioning of biomass, yield & quality of Radish Seed Crop is meager. The literature pertaining to different aspects of the problem under study has been reviewed. Pawar *et al*. (2000) [16] reported that growth characters like plant height and leaf area per plant significantly increased in irrigation treatment at 0.6 IW/CPE over 0.4 IW/CPE but it was at par with irrigation treatment at 0.8 IW/CPE ratio during 1997-98. Similar finding has been reported by Patel and Upadhyay (1991) [15].

Kantwa and Meena (2002) [6] found that irrigation at branching, flowering and pod formation stages in mustard significantly increased all the growth parameters (plant height, primary & secondary branches per plant and dry matter accumulation) over the irrigation at branching & flowering and branching & pod formation stages. These findings are in agreement with the results of Malavia *et al.* (1998) [9]. Pawar *et al.* (2000) [16] reported that yield attributing characters like 1000 seed weight & seed yield were significantly superior under irrigation at 0.6 IW/CPE ratio over 0.4 IW/CPE but at par with 0.8 IW/CPE. Similar results were also reported by Parihar (1991) and Reddy and Sinha (1989). It was observed that at 0.8 IW/CPE adequate moisture available might have facilitated more absorption of nutrients and there by improved all yield contributing characters & finally seed yield. Singh and Saran (1993) [28] reported that application of irrigation upto 0.2 IW/CPE to *Brassica campestris* var. toria, significantly increased siliquae per plant, siliqua length, 1000-seed weight and seed yield. When irrigation was applied at flowering + fruit setting, the yield attributed such that siliquae per plant, siliqua length and 1000-seed weight of mustered (*Brassica juncea*) increased (Tomar *et al.*, 1992) [30]. Singh *et al*. (1990) [27] at Hisar reported that highest seed yield of 1.25 t/ha was obtained with irrigation at ID/CPE of 0.6 compared with 0.17 t with no irrigation in *Brassica campestris* cv. Sangam. Raja and Bisnoi (1990) [17] observed seed yield of 1.16-1.38 and 0.71-0.88 t/ha in *Brassica campestris* var. toria cultivars when irrigation was given at 150 or 200 mm CPE, respectively compared with 0.51-0.68 t/ha under rainfed conditions.

Padmani *et al*. (1992) [13] reported significant increase in seed yield of Br*assica campestris* cv. Kranti with increase in irrigation levels upto 0.4 IW/CPE ratio. The percent increase in seed yield over control was 21.74 and 53.58 under 0.2 and 0.4 IW/CPE ratios, respectively. Singh *et al*. (2002) [24] reported that water stress at pod form stage drastically reduced the seed yield by 23.7% compared with four irrigations (21.5 q/ha). Nitrogen and phosphorus content in straw and seed were significantly increased with increase in irrigation frequency and were significantly highest with four irrigation given at presiding, at vegetative 50% flowering and grain filling stages than all other stages (Giri *et al.*, 2003) [4]. Pawar *et al.* (2000) [16] revealed that highest water use efficiency was recorded under scheduling of irrigation at 0.4 (22.5 kg/ha/cm) & 0.6 (16.56 kg/ha/cm) IW/CPE ratios during 1996-97 and 1997-98 respectively. Rana *et al.* (1991) [18] reported that consumptive use of water of *Brassica juncea* increased with increase in water supply to crop. The highest consumptive use (189.8 mm) was recorded at 0.6 IW/CPE ratios, followed by 0.4 IW/CPE (164.3 mm) and no irrigation (120.9 mm). Ram *et al.* (1993) observed that under Hisar conditions consumptive use of water increased progressively with increased in irrigation levels (from one irrigation to two irrigations), but water use efficiency decreased by increasing irrigation levels. Similar results were obtained by Singh (1992) [25] at Hisar. Raut *et al.* (2000) [19] revealed that consumptive use of water increased with increase in irrigation frequency. Water use efficiency was the highest with two irrigations applied at pre-flowering and siliqua setting stages in mustard. Nehra *et al.* (1999) [12] also reported the increase in plant height with increased level of N & delayed in flowering up to 120 kg N/ha, whereas. Pawar *et al.* (2000) [16] reported the higher seed yield (10.10q/ha) in 50 kg N + 40 kg P_2O_5 + 40 kg S/ha treatment whereas Sharma and Raina (1993) reported that application of N beyond 75kg/ha did not increase the seed yield significantly. Gill *et al.* (1995) [3] observed significantly increase in seed yield with the growth of both nitrogeneous and phosphatic fertilizer up to 75 kg N & 20 kg P_2O_5/ha beyond that the response was not significant. Highest seed yield (1.16 t/ha) was obtained in Bangladesh when 175:100:125 kg/ha NPK were used by Ara *et al*. (1999) [1], whereas, Jadhao *et al*. Shrinivas and Naik (1990) reported the markedly increased harvest index with 150 kg N/ha but increase was marginal with potassium fertilization. Sharma and Kanaujia (2000) [22] results indicated the maximum values with respect to number of seeds per pod, number of pods per plant, seed yield per plant as well as per hectare when nitrogen was applied @ 200 kg/ha. Sharma and Lal (1990) recorded the maximum 1000 seed weight with 150 kg N/ha and were found significantly higher than the other lower level. Gill *et al.* (1996) reported the increase in seed production of radish by applying nitrogen up to 75 kg/ha and P up to 20 kg/ha & decrease in yield beyond it, whereas, Singh *et al.* (1985) [26] obtained the highest seed yield (10.39 q/ha) with the highest NP rate i.e. N @ 80 kg/ha & P @ 60 kg /ha. Sharma *et al.* (1990) [23] found the highest 1000 seed weight (11.65g) with highest N application (150kg N/ha). Nehra *et al.* (1999) [12] recorded the maximum number of pods, seed yield per plant and test weight with 80 kg N/ha, which were at par with 120 kg N/ha, whereas, growth of seed was not influenced by different levels of nitrogen. Lowato *et al.* (1994) reported the increase in seed yield along with increasing amount of N up to 150 kg/ha. Bhardwaj (1990) [2] and Singh *et al.* (1990) [27] observed increase in seed yield of

Brassica juncea upto 90 and 80 kg N/ha, respectively. While Narang and Gill (1991) [11] reported that seed yield in *Brassica napus* L. registered a significant increase upto 150 kg N/ha.

Mohapatra (1993) [10] observed significant response of nitrogen. Application of nitrogen @ 60 kg/ha significantly influenced the seed yield of mustard as compared to 30 or 45 kg N/ha did not influence the seed yield significantly. Increase in yield contributing characters of mustard (*Brassica juncea*) viz., number of siliquae per plant, number of seeds per siliqua and test weight, with increasing doses of nitrogen has also been noticed by Bhardwaj (1990) [2] and Singh *et al.* (1990) [27]. Number of siliqua per plant, number of seeds per siliqua, seed yield, test weight and harvest index increased significantly up to individual application of 10 t FYM + 30 kg N & 20 kg P2O5/ha (Jat *et al.*, 2000) [5]. The maximum seed yield of 6.65 q/ha was registered under N 150 P 30 kg/ha and closely followed by N 150 P 60 kg/ha (6.55 q/ha). Both these treatments were superior to the seed yield obtained under sole application either of N or P (Sharma, 2000) [22].

The positive influence of N, P and K levels were found to increase the NPK contents in leaf & root (Patil and Patil, 1986), whereas, Majidul *et al*. (2001) [8] did not find the interaction effect of irrigation and K application on radish in Bangladesh but the highest yield of 30.1 kg/ha was obtained under the highest level of irrigation and K application (Four irrigation with 160kg K_20/ha) as the positive effects of both treatments on the radish yield. Singh (1992) [25] at Hisar observed significant interaction effect s of irrigation and nitrogen levels on seed yield of Raya. Under unirrigated condition, a significant increase in seed was observed up to 60 kg N/ha, whereas, under irrigated condition, significant increase was found up to 90 kg N/ha. Sharma (2000) [21] studies the interaction effect of nitrogen and phosphorus on seed yield in radish and resulted in maximum seed yield of 6.65 q/ha under N 150 P 30 kg/ha and closely followed by N 150 P 60 kg/ha (6.65 q/ha).

Conclusion

On the basis of data of two years field research under the agro climatic condition of Hisar, Haryana, it may be concluded that for obtaining the higher seed yield of radish cv. Hisar Selection-1, the crop should be irrigated at ID/CPE 0.8 & fertilized with 25%> recommended fertility levels during winter season.

References

1. Ara N, Ali MO, Ali MM, Barher MK. Effect of spacing and fertilizer levels on yield and quality of radish seed. Bangladesh J Sci. & Indu. Res. 1999; 34(2):174-178.
2. Bhardwaj GS. Response of improved varieties of mustard to different levels of nitrogen under northern conditions of Madhya Pradesh. Haryana J Agron. 1990; 26:62-65.
3. Gill SS, Gill BS, Brar SPS, Balwinder Singh. Nitrogen and phosphorus requirement of radish seed crop. *Seed Res.* 1995; 23(1):47-49.
4. Giri MD, Hamid Abdul, Giri DG, Kuwar RP, Sajid Mohmmed. Effect of irrigation and sources of sulphur on quality and uptake of nutrients of mustard. Soils and Crops. 2003; 13(1):131-134.
5. Jat RS, Khangarot SS, Rathore SS. Effect of different fertility levels on growth and yield of mustard [*Brassica juncea* (L.) Czern & Coss]. Ann. Agric. Res. 2000; 21(3):421-423.
6. Kantwa SR, Meena NL. Effect of irrigation, phosphorus and PSB on growth and yield of mustard. Ann. Agric. Res. New Series. 2002; 23(3):456-460.
7. Lovato A, Montanari M, Miggiano A. Nitrogen fertilization of seed radish (*Raphanus sativus* L.): Effects on yield and N-content in seed plant and soil. Acta. Hort. 1994; 362:117-124.
8. Majidul SB, Sirajul KAJM, Majidul HK, Tofazzal H, Kazuhika R. response of radish to varying levels of irrigation water and fertilizer potassium on clay terrace soil of Bangladesh. Communications in Soil Sci. and Plant Analysis. 2001; 32(17-18):2979-2991.
9. Malavia DD, Patel JC, Vyas MM. Studies of irrigation, nitrogen and phosphorus levels on growth and yield of mustard. Indian J Agron. 1998; 33:245-248.
10. Mohapatra AK. Response of late sown irrigated mustard (*Brassica Juncea*) to levels of nitrogen and time of application in coastal Orissa. Indian J Agron. 1993; 38(3):496-497.
11. Narang RS, Gill MS. Nitrogen response, stress and use efficiency studies in Gobhia-sarson (*Brassica Juncea* L.) grown under different levels of nitrogen. *Fert. News.* 1991; 36(10):37-45.
12. Nehra BK, Malik YS, Singh Narendra. Effect of root age and nitrogen on seed crop of radish (*Raphanus sativus* L.). cv. Pusa Chetki. Haryana J Hort. Sci. 1999; 28(3-4):238-240.
13. Padmani DR, Porwal BL, Jain PM, Patel JC. Effect of irrigation and nitrogen on yield and yield attributes of mustard (*Brassica Juncea*). Indian J Agron. 1992; 37(3):109-112.
14. Parihar SS, Tripathi RS. Influence of irrigation and nitrogen on yield, nutrient content and oil yield of mustard. Indian J Agron. 1989; 34(1):45-49.
15. Patel PM, Upadhyay PN. Response of mustard to irrigation scheduling based on IW/CPE ratio under varying levels of nitrogen and phosphorus. M.Sc. (Agri.) Thesis, Department of Agronomy, G. A. U., Anand, 1991.
16. Pawar SB, Shelke DK, Neharkar PS, Karanjikar PN. Water use – efficiency under varied irrigation schedules and fertilizer levels in Indian mustard (*Brassica juncea* L.). Soils and Crops. 2000; 10(2):231-235.
17. Raja V, Bishnoi KC. Response of some promosing rape (*Brassica campestris* L. var. toria) genotypes grown under irrigated dry conditions. *Agric. Res.* 1990; 11(3-4):249-255.
18. Rana DS, Singh HP, Ahlawat IPS. Effect of irrigation plant density and nitrogen application on water use, yield and yield attributes of mustard (*Brassica* j*uncea*). Indian J Agron. 1991; 36:138-142.
19. Raut RF, Hamid Abdul, Ganvir MM, Wanjari SS, Hadole SS. Consumptive use, water use efficiency, seed yield and quality of mustard as influenced by irrigation and sulphur application. J Soils and Crops. 2000; 10(2):252-255.
20. Reddy BN, Sinha MN. Effect of irrigation and fertilization on yield and economics of Indian mustard. J Oilseed Res. 1987; 4:202-212.
21. Sharma AK. Effect of nitrogen and phosphorus on seed yield in radish (*Raphanus sativus* L.). Agric. Sci. Digest. 2000; 20(1):46-49.
22. Sharma SK, Kanaujia SP. Response of transplanting time under different nitrogen fertility regimes on certain ancillary characters, seed yield and quality of radish seed. Ann. Agric. Res. 2000; 21(4):465-468.
23. Sharma SK, Lal G. Effect f certain cultural practices on

the test weight of radish seed. *Seed Res.* 1990; 18(2):154-156.
24. Singh Fateh, Sinsinwar BS, Premi OP. Effect of irrigation schedule on growth, yield and yield contributing characters of Indian mustard. Ann. Agric. Res. New Series. 2002; 23(3):411-414.
25. Singh J. Response of mustard genotypes to nitrogen under varying moisture regime. Ph.D. Thesis, HAU, Hisar, 1992.
26. Singh KP, Malik YS, Yadav PS. Effect of fertility levels on root and seed crop in radish seed production (*Raphanus sativus* L.). Haryana J Hort. Sci. 1985; 14(1-2):137-140.
27. Singh M, Singh BP, Singh R. Effect of row spacing nitrogen and phosphorus on the growth and yield of raya (*Brassica juncea* L.) Haryana J Agron. 1990; 6:89-91.
28. Singh S, Saran G. Effect of irrigation, nitrogen and sulphur levels on growth, yield attributes, yield, quality and water use of toria (*Brassica campestris* sub sp. Oleifera var. toria). Indian J Agron. 1993; 38(3):417-421.
29. Srinivas K, Naik LB. Growth and yield of radish (*Raphanus sativus* L.) in relation to nitrogen and potash fertilization. Indian J. Hort. 1990; 47(1):114-119.
30. Tomer S, Tomar S, Singh S. Effect of irrigation and fertility levels on growth, yield and quality of mustard (*Brassica juncea*). Indian J Agron. 1992; 37(1):76-78.