STUDIES ON GROWTH AND PRODUCTIVITY OF MUSTARD UNDER DIFFERENT MANAGEMENT PRACTICES

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CERTIFICATE

I hereby certify that the thesis entitled **"Studies on growth and productivity of mustard under different management practices"** *submitted for the award of degree of Doctor of Philosophy in Agronomy of the Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, is a record of bonafide research work carried out by Sri Sanjoy Ghosh under my guidance and supervision. No part of this thesis has been submitted for any other degree or diploma. The help and source of information, as have been availed of during the course of this investigation, have been duly acknowledged.*

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APPROVAL OF EXAMINERS FOR THE AWARD OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN AGRICULTURE (AGRONOMY)

We, the undersigned having been satisfied with the performance of Sri Sanjoy Ghosh, in the Viva-voce examination conducted to day, the .... recommend that the thesis be accepted for the award of the degree.

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LIST OF ABBREVIATION USED

Days after sowing	DAS
Square metre	Sq. m
Grams	gm
Kilogram	kg
Tonnes	t
Hectare	ha
Nitrogen	N
Phosphorus	P
Potassium	K
Not significant	NS
Standard error of mean	S.Em (±)
Critical difference	C.D.
And others	*et al.*
Centimetre	cm
Cultiver	cv.
Crop growth rate	CGR
Leaf area index	LAI
Net assimilation rate	NAR
Number	No.
Rupees	Rs.

ABSTRACT

In the subtropical climate of eastern India with short and mild winter field experiments were conducted in sandy clay loam soil of high percolation rate, to analyse the growth and evaluate the productivity of mustard crop under different management practices.

Water management with two irrigation increased the seed yield to the tune of 23.92 per cent in comparison to mustard seed yield in conserved residual moisture soil; one irrigation recorded a negative increase of 11.09 per cent.

Fertilizer management in irrigated soil with split application of nitrogen (80Kg N/ha) increased the seed yield to the extent of 56 per cent in comparison to basal application of nitrogen (60 Kg N/ha) in conserved residual moisture soil. Split application of nitrogen (60Kg N/ha) replacing the practice of top dressing with foliar spray in conserved residual moisture soil showed 30.01 per cent increased seed yield. Foliar spray alone showed only 11.47 to 13.49 per cent increased seed yield.

Weed infestation was managed effectively by herbicide pendimethalin and close plant spacing. Herbicide pendimethalin increased the seed yield to the tune of 41.78 per cent in irrigated soil in comparison to linuron in conserved residual moisture soil. Pendimethalin in conserved residual moisture soil showed only 18.39 per cent increased seed yield.

Crop management practice with proper plant spacing in irrigated soil showed 23.69 per cent increased seed yield in comparison to optimum plant spacing in conserved residual moisture soil; close plant spacing increased the seed yield to the tune of 15.56 per cent in conserved residual moisture soil.

The uptake of N, P and K were associated with seed yield differences due to different treatments under different management practices.

The seed yield increased of mustard due to different treatments under different management practices was mainly due to yield increasing component and growth attributes.

Close plant spacing in conserved residual moisture soil showed highest increase in economic return (28.69%).

The economic return per rupee invested was fairly high in conserved residual moisture soil in different management practices except fertilizer management practice with split doses of nitrogen and use of herbicide pendimethalin in irrigated soil; however, the differences were not appreciable.

Where adequate water supply is assured, the resourceful farmers with proper crop management practices may achieve maximum high productivity and economic return of mustard. When water is scarce, the farmers with limited resources may raise mustard crop in conserved residual moisture soil with proper crop management practices including close plant spacing and foliar spray of nitrogen in combination with basal application of N for substantial high seed yield (1284 Kg/ha) and high economic return per rupee invested.

CHAPTER I

INTRODUCTION

Indian agriculture has entered an era of science and technology and market oriented economy from the subsistence traditional agriculture. We can look back at our achievements in the field of agriculture in the second half of this century with satisfaction. Undoubtedly there has been a significant improvement in the performance of India's vegetable oil sector in the last one decade; thanks to the Technology Mission on oilseeds (TMO) which has triggered the mechanism to increase production and productivity of all the oilseed crops. Ever since the TMO came into existence in May, 1986, oilseed production has more than doubled from 10.6 million tonnes to about 24 million tonnes. However, indigenous production is inadequate to meet the demand for edible oils. To meet the demand last year import of vegetable oils had to be made for 8 lakh tonnes (Reddy, 1996).

Indian oilseeds scenario has reflects a dramatic change with a production of 18.28 million tonnes in 1991-92 and 21.5 million tonnes in 1993-94 as against a target of 22.0 mt in 1994-95 and 23.0 mt by the end of the eight five year plan (Economic Survey, 1994-95). The present level of production of edible oilseeds is still in short of the country's demand. The projected demand for oilseeds by 2000 A.D. is 26 mt, and this may go up further with the increase in per capita income. The demand at the present consumption level by 2020 A.D. is placed at 34 mt of oilseeds which means an addition of 12 mt to the present production level or an annual increase by 2.5%. India is spending crores of rupees on import of edible oils every year. Research had shown that the production of oilseeds could atleast be doubled by adopting improved crop production technologies available now (Tandon, 1990). The progress in terms of increasing production and productivity of rapeseed-mustard in the country is to be streamlined to produce 26 mt of edible oilseeds to meet the domestic requirement of fats and oils by 2000 A.D. Therefore, a sustainable production should be the strategy in production technology of oilseeds.

High instability in oilseed production is due to the fact that, it is mainly grown in marginal lands under rainfed condition, particularly in low and uncertain rainfall area with minimum or no use of fertilizers (Ninan, 1989) . Thus, while a sizable portion of wheat (70%) and rice (41 %) benefited from assured irrigation, a vast portion (70%) of the area under oilseed crop is subject to the vagaries of monsoon. Hostile condition of crop growth prevalent on dry land results in low yield.

The current productivity level per hectare of oilseeds in India are about one-third of the world's best levels and can be significantly improved. Inspite of several possibilities, area expansion under oilseed has limited scope. Bringing larger area under irrigation can perhaps be achieved over a long period. Past performances is a pointer in this regard. A possible surebet, therefore, should be to increase the yield levels through adoption of viable and well founded technologies relevant to the Indian farmer and environment. Application of balanced dose of fertilizer (both organic and inorganic sources) play a critical role in determining the extent of yield advantages over unplanned use of it. To explore the feasibility of increasing production, we are to employ best of our available technology incorporating with the utmost management and to culminate a definite search in the arena of the agronomic requirement of this crop. In India the production of rapeseed-mustard being 5.6 mt in 1995-96 (The Hindu Survey of Indian Agriculture, 1996). In West Bengal, the area under rapeseed-mustard is 3.777 lakh hectares with a total production of 2.986 lakh tonnes, accounting an average yield of 944 kg/ha (Economic review, 1995-96). This much production is only 5.1% of the total production of the country.

The productivity of mustard can be increased by proper fertilizer and water management. The mustard crop is responsive to fertilizers especially to nitrogen and sulphur (Dubey and Khan, 1993). The concentration of plant nutrients and the amount of nutrients being removed by a particular crop may be a helpful guide for formulation of a sound fertilizer management programme (Tandon, 1989). Mustard are generally grown rainfed with nominal use or no use of fertilizers. But the nutritional investigation and general experience show that use of fertilizers gives substantial increase in yield.

Nitrogen is an important constituent of protein for which the plant take inorganic nitrogen in the form of ammonium or nitrate. But sometime higher protein content in mustard shows a depression in oil content providing an inverse relationship between protein and oil content. It indicates clearly that from the point of view of higher net oil recovery and quality, application of nitrogen in required quantity and in due time is very much essential. The method and time of application are the most important of all the factors that governs the response pattern of applied nitrogen.

Indian mustard also response to irrigation (Prasad and Eshanullah, 1988; Parihar and Tripathi, 1989; Sharma and Kumar, 1989). Only 23.9 percent of the area under oilseeds are now irrigated (It was only 14.3% in the eighties). Provision of protective irrigations through optimum use of water resources during long dry spell can increase productivity. The mustard crop that can successfully extract moisture from deeper zone of soil profile is grown availing residual moisture of Kharif season, but responses very well when irrigated. Similarly raising of mustard with little quantity of fertilizer although is the practice but the yield is multiplied if fertilizer is applied in the field with assured irrigation. Along with the application of balanced fertilizers, the influence of plant density on yield and yield components can not be ignored. It is necessary to find out the optimum plant population without which optimum yield may not be obtained even under optimum fertilizer doses. The residual moisture conservation is also an important factor for sound fertilizer and water management. Thus, proper crop geometry and control of weeds need elaborate study as uncontrolled weeds on an average reduce the yield of Indian mustard by 33.5%. All these facts revealed that there is an ample scope for increased yield of mustard (Tandon, 1989) by proper adjustment of plant density and fertilizer in accordance with the availability of water. However, very little elaborate information is available on the effect of water management, method of application of nitrogen, weed management, plant geometry and their interaction effects on the growth and productivity of mustard, under local condition of short winter and unfavourable rainfall pattern for boosting the productivity of mustard corp. Keeping this idea in view the present investigation was undertaken at the District Seed Farm of Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during the rabi season of 1995-96 and 1996-97 with the following objectives :

i) Detailed study to find some ways and means for boosting the productivity of mustard crop grown under residual moisture condition by suitable crop geometry, weed control and fertilizer management practices, keeping in view, the local conditions of the region such as short winter and rainfall pattern and thus a well tested and best adopted high yielding mustard cultivar has also to be kept in mind which can help to boost the yield attributing factors under study.

ii) Keeping in view the limits of boosting production of mustard crop grown under moisture stress condition with all input and technical know how, further elaborate study to meet the demand for very high productivity of mustard by eleminating the moisture stress condition with irrigation as a first step followed by suitable crop and fertilizer management practices.

iii) To compute the economics of all measures for increased productivity of mustard crop, grown with and without moisture stress condition and there by formulation of a economic optimum level of all factors facilitating increased mustard production both for poor and resource full farmers.

CHAPTER II

REVIEW OF LITERATURE

The mustard crop that can successfully extract moisture from deeper zone of soil profile is grown availing residual soil moisture of *kharif* season, but responses very well when irrigated. Similarly, raising of mustard with little quantity of fertilizer although is the practice but the yield is multiplied if required fertilizer is applied in proper time and with proper method in the field with assured irrigation. Hence, in this chapter an attempt has been made to understand the major two crop production inputs i.e. irrigation and nitrogen and their combined effect on growth, yield in the present context of limited use of these two inputs. An attempt has also been made to review the crop geometry for rainfed mustard crop and the effect of weed control on the growth and productivity of the crop.

2.1 Effect of Nitrogen on Growth and Productivity of Mustard

2.1.1 Effect of nitrogen on growth attributes of mustard

The application of N encouraged growth of mustard including dry matter (Maini *et al.,* 1964) and the effect was proportionate to the dose of N applied (Maini *et al.,* 1965). Allen *et al.* (1971) reported that application of N promoted growth and increases both LAI and CGR. It increases production of seeds by a large number of siliqua although it had a little effect on average siliqua weight or average seed weight (Allen and Morgan, 1972). Singh (1977) found that application of nitrogen on raya significantly influenced the secondary branches per plant and 1000-grain weight. 1000-grain weight decreased with increasing doses of N in the first year, but it was increased in the second year. However, flowering and maturity were delayed where as plant height, primary branches per plant and number of grains per siliquae increased with the increasing levels of N.

Major (1977) reported that LAD will be greater due to higher LAI or LAI for a longer period. CGR was generally greater near the time of maximum LAI and tended to decrease as LAI decreased. The decrease in CGR suggested that leaves were the most important source of photosynthesis and maintenance of a large and photosynthetically efficient leaf area during the period of flowering is necessary for higher yield of this crop.

Chauhan and Bhargava (1984) reported that dry matter yield was highest when rai was fertilized with 75 kg N/ha and harvest index ranged from 0.24 to 0.38 on a biomass basis. Singh *et al.* (1985) reported an increased branches per plant with the increase in N application. Malvia *et al.*. (1988) reported that all growth and yield attributes except, 1000-seed weight were significantly influenced by application of nitrogen. Number of primary and secondary branches/plant, plant height and seed weight/plant responded to nitrogen significantly up to 50 kg N/ha. The results are in conformity with the studies conducted by Patel *et al.* (1980), Bhati and Rathore (1982), Chaniara and Damor (1982) and Patel (1984).

Khanpara *et al.* (1993) reported that plant height, primary branches per plant and secondary branches per plant were increased with an increase in N levels. They also reported that dry matter production per plant and leaf Area Index of mustard plant at 50% flowering stage were significantly increased with increase in levels of N and N @ 60 kg/ha being superior to the other levels, *i.e.* 0, 20 and 40 kg N/ha.

2.1.2 Effect of nitrogen on yield attributes of mustard

Nitrogen has a great impact on yield attributing parameters of mustard. Singh (1977) found that nitrogen at 40 and 80 kg/ha gave significantly higher yield of toria over no nitrogen application. He also added that the ancillary plant characters viz. primary and secondary branches, number of siliqua/plant, grains/siliquae and 1000-seed weight, all these jointly attributed towards the more yield. Vir and Verma (1979) reported that the increase in levels of nitrogen favourably influenced the yield attributes, seed yield and nitrogen content in seed and stover under rainfed conditions at Agra region. Maiti *et al.* (1980) reported that average 1000-seed weight was lowest (3.88 g) with 0 kg N/ha and highest (4.17 g) with 150 kg N/ha along with 50 kg $P_2 0_5$ + 50 kg $k_2 0$/ha in mustard. On the otherhand Mondal and Gaffer (1983) reported that fertilizer had little effect on 1000-seed weight (2.60 - 2.78 g) but treatments with greater than 105 kg N/ha gave the highest seed yields (greater than 1.2 t/ha). Singh *et al.* (1985) reported that number of siliqua/plant and seed weight was increased due to increase in levels of N. Khanpara *et al.* (1993b) reported that N @ 60 kg/ha significantly improved the yield parameters, viz. siliqua/plant and seed yield/plant and 1000-seed weight on clay-loam soil of Udaipur.

2.1.3 Effect of nitrogen on seed yield of mustard

Nitrogen is one of the key elements necessary for growth and development of rapeseed and mustard. Response of Brassica to N has been reported by several workers in different agroclimatic regions of the country. Maini and Singh (1959) found that the yield of rai and brown sarson increased by 30% with an application of 60 lb N/ac. The optimum dose of n were 81.6 lb/ac for rai, 59.4 lb/ac for sarson and 24.0 lb/ac for toria. However, the input-output relationship between the dose of N and the yield of seed was found to be linear by Maini and Negi (1957) and Ghosh (1970).

Sharma (1968) studied the response of mustard to different levels of N, P and K on Laha-101 variety at Meerut and recorded highest yield and profit from 45 kg N/ha. Jain *et al.* (1969) compared two mustard varieties, 'T-11' and 'Appressed mutant' at 0, 25, 75 and 100 kg N/ha at Kanpur and obtained linear response up to 100 kg N/ha. Singh and Mathur (1971) found a dose of 140 kg N/ha is quite economical which increased the yield of mustard by 401 kg/ha over zero level of nitrogen. Mathur and Tomar (1972), on the basis of three years study, revealed that a dose of 37.5 kg N/ha was optimum of RI-18 variety of mustard, while for rai still a higher dose of 80-100 kg N/ha needs to be given for maximum returns. Bhan (1976) found application of 50 kg N/ha exhibited a better effect on the yield of brown sarson over 25 kg N/ha. Bhola *et al.* (1977) reported that 80 kg N/ha was the optimum dose for raya, among four levels of N tried (0, 40, 80 and 120 kg N/ha), under sandy-loam soil. Singh *et al.* (1978) reported that yields of mustard were higher with N applied in a single dressing at sowing (1.7 t/ha) than when applied in two (1.48 t/ha) or three (1.43 t/ha) split dressings. N fertilization at 60 kg /ha significantly increased the total dry matter (Vir and Verma, 1979b). Maity *et al.* (1980) reported that seed yield was highest at 150 kg N/ha and lowest in control. Sengupta *et al.* (1983) found that the application of N significantly increased the seed yield over control, but there was no significant difference among 25 kg, 50 kg and 75 kg N/ha levels. Nayak and Mondal (1985) reported that mustard varieties like B-85, gave highest yield under rainfed condition at 60 kg N/ha along with 30 kg each of P_2O_5 and k_2O/ha. Samui *et al.* (1986) also reported beneficial effect of N in increasing the seed yield of mustard. Malavia *et al.*(1988) reported that, application of nitrogen significantly influenced seed yield of mustard. Seed and Stover yields increased with increasing levels of nitrogen but the significant increase was noticed up to 50 kg N/ha. Rathore and Manohar (1990) obtained an increased yield of mustard (*Brassica juncea*) with increasing N rate up to 120 kg/ha. Patel *et al.* (1980), Bhati and Rathore (1982) and Patel (1984) have also reported similar findings elsewhere.

Increasing N rates from 0 - 90 kg/ha increased seed yields of Brassica juncea from 245 - 277 to 628 - 778 kg/ha (Sounda *et al.*, 1989). Increasing N rates increased the yield of this crop and the increase was steady and linear up to the application of 100 kg/ha of N (Kharodia and Patel. 1990). Eshanullah *et al.* (1991) found quadratic response of mustard to N application and the net profit was maximum with 80 kg N/ha. But N fertilization at 60 kg/ha was optimum and increased the yield contributing characters over a dose of 30 kg/ha (Sandhu and Singh, 1960; Singh and Prasad, 1975; Vir and Verma, 1979; Nayak and Mondal, 1985) .

2.1.4 Effect of method of N application on yield

Seed yield of rapeseed was higher with a single top dressing of N than split application (Goralski and Mercik, 1970). Lahiri and De (1971) reported that soil application of N along with foular sprays at 40 DAS gave higher seed yield than that obtained with only soil application. However, Franck and Becker (1982) found that split application did not give better response than single application at the beginning of growing period. The increase in yield due to application of N, half of the recommended dose at sowing and remaining half at 25 DAS, over single application, was evidenced by Mondal and Gaffer (1983). However, rates and methods of N application had no significant effect of seed yield of rapeseed (Garcia and Alcantona, 1983). But Gaffer and Razzaque (1984) found that soil application gave slightly better result than foliar dressings. Berti and Mosca (1987) reported that splitting the N, one-third before sowing and two-thirds as a top dressing improved fruit setting more than that in total N application either before sowing or as top dressing.

2.1.5 Effect of nitrogen on oil content and quality of mustard

The oil content and quality charters of rapeseed-mustard are greatly influenced by the application of N. A study carried out under the agencies of I.C.D.C (1962) at Patiala revealed that there was a decrease of about half a percent in oil content in seed of Brassica campestris var. toria for every increase of 30 kg N/ha. Similar result was also obtained by Sinha *et al.* (1962). Bhatty (1964) reported an increase in protein content and a decrease in oil content due to the application of N. Oil content of raya decreased with the increasing doses of nitrogen (Rathi *et al.,* 1970; Bhola *et al.*, 1977), whereas oil content and cake yield/ha increased linearly with increasing rates of N as reported by Bishnoi and Singh (1979) . This was indicated by the fact that oil and cake yield were governed by seed yield of mustard rather than its oil content. Similar results were also obtained by several workers (Yadav, 1975; Singh and Rathi, 1984) .

Singh and Yusuf (1979) reported that seed oil content tended to increase with low levels of N up to 30 kg/ha. Higher N levels (48 and 60 kg/ha) reduced the seed oil considerably. Aulakh *et al.* (1980) reported that although N had little effect on the oil content, but total oil production was increased many fold due to application of N. Vir and Verma (1981) denied any effect of nitrogenous fertilizer on oil content. In an experiment conducted by Parihar and Tripathi (1989), oil content in general decreased with a corresponding increase in the levels of N. There was a sharp fall of the order of 3.27% on an average being recorded when the N level was increased from 30 to 60 kg /ha. Rana *et al.* (1991) found that seed oil content of *B. juncea cv.* Pusa Bold were decreased with the increase in N rates of 0, 50, 100 or 150 kg N/ha. Padmini *et al.* (1992) reported that, increase in nitrogen fertilization decrease the oil percentage and differences were significant when the dose was increased from 30 to 60 kg/ha.

2.2 Effect of Irrigation on Growth and Productivity of Mustard

2.2.1 Scheduling of irrigation on the basis of critical stage approach

Out of different approaches used for scheduling irrigation in rapeseed-mustard, irrigation on the basis of critical physiological stage is considered very much practically appropriate provided the depth and timing of irrigation are taken care of.

Chauhan and Bhargava (1986) reported that rapeseed and mustard cultivars are morphologically determinate but the growth of raceme, which is a corymbose type is indeterminate. Therefore, identification of specific stage of growth is difficult. Four physiological stages such as vegetative, flower initiation, maximum flowering and siliqua development have been identified as most critical. Irrigating the mustard crop with one irrigation at flowering stage and with two irrigation's viz. one at rosette stage and other at flowering stage, it was seen that reducing the irrigation from two to one and zero reduced the yield by 15% and 20% respectively (Singh and Dixit, 1989). Sharma and Kumar (1989) reported that average seed yield of mustard was 13.7 q/ha with irrigation over no irrigation (7.7 q/ha) .

2.2.2 Effect of irrigation on growth and development of mustard

2.2.2.1 Plant height

The average plant height increased from 179 to 204 cm with the application of one irrigation over no irrigation (Parihar *et al.*, 1981) . The plant height increased from 70 cm to 82.4 cm and 91 cm by applying one or two irrigations respectively over control. Reddy and Sinha (1987) observed a plant height of 179 cm with irrigation at 0.6 IW/CPE ratio over no irrigation where the plant height was 171 cm. Internal soil moisture deficit leads to lower plant height (Malavia *et al.*, 1988). Application of two post-sowing irrigations at several locations increased the plant height of rapeseed mustard significantly over control (Sharma and Kumar, 1989; Dongale *et al.*, 1990 ; Tomer *et al.*, 1992 ; Singh *et al.*, 1992 ; Padmini *et al.*. , 1992).

Sharma (1991) observed 28% increase in plant height of mustard *cv.* Varuna over control due to application of two irrigations at 30 and 60 DAS. Agarwal and Gupta (1991) reported that applications of two irrigations increased the plant height of mustard cv. Varuna by 7.5% over control (145.6 to 156.4 cm) . Contribution of three irrigations to plant height was more than two irrigations (Tomer *et al.*, 1991) when supplied to toria variety T-9 at 20, 40, and 60 DAS. The plant height was raised from 79.1 to 198.4 cm. (36.9%). Increase of plant height with the application of irrigation in rapeseed-mustard over no irrigation was reported by several other workers (Krogman and

Hobbs, 1975; Mehrotra *et al.,* 1978; Bhati and Rathore, 1982; Chaniara and Damor, 1982; Rao and Agarwal, 1985; and Samui *et al.*, 1986).

2.2.2.2 Number of branches per plant

Both primary and secondary branches of rapeseed and mustard were favourably influenced by irrigation. Number of primary branches were more by 26% and number of secondary branches were more by as high as 106% due to application of two irrigations. There was positive correlation of yield with no. of branches per plant (Roy and Tripathy, 1985). Samui *et al.,* (1986) reported that application of two irrigations to mustard increased the number of primary branches per plant from 3.85 in control plot to 4.85 and the percentage increase being 26. Irrigation in general significantly induced more number of primary branches and yield attributing characters than unirrigated, because plant grow better with irrigation (Singh and Srivastava, 1986). Prasad and Eshanullah (1988) reported that the number of primary branches were not affected with either one or two irrigations. However, the number of secondary branches were more under two irrigations. Increase in frequency of irrigation increased in number of branches per plant (Sharma and Kumar, 1989). Three irrigations were more beneficial than two irrigations. Application of three irrigations at 20, 40 and 60 DAS increased the number of primary branches by 124.4% and number of secondary branches per plant by 117% over control (Tomer *et al.,* 1991). Sharma (1991) observed that the number of branches per plant of mustard cv. Varuna was increased from 9.7 under no irrigation to 20.0 (106 %) due to application of two irrigations at 30 and 60 DAS. Agarwal and Gupta (1991) reported 38.5% increase in number of branches per plant of mustard cv. Varuna due to application of two irrigations as compared to no irrigations. Tomer *et al.,* (1992) reported that number of branches per plant of mustard increased significantly over control due to application of two irrigations.

2.2.2.3 Dry matter production

The first requisite for high yield is a high production of total biomass per unit area. Photosynthesis is the basic process for the building of organic substances by the plant, whereby, sunlight provides the energy required for reducing CO_2, with sugar as the end product of the process. This sugar serve as organic compound of the plant. As moisture stress increases, photosynthesis drops to the compensation point (Pallas *et* *al.*, 1962). The increase in dry matter was due to more availability of soil moisture and nutrients. An adverse water regime also reduces leaf area and hastens leaf senescence thereby decreased the productivity of the crop to a greater extent reducing net assimilation rate (Fisher and Hagan, 1965). Water stress can affect photosynthesis directly by affecting various biochemical process involved in photosynthesis and indirectly by reducing the intake of CO_2 through stomata as a result of their closure in response to water stress. The translocation of assimilates can also be affected by water stress and the resulting assimilate saturation in the leaves may limit photosynthesis (Hartt, 1967). Irrigation prolongs life of leaves which make an important contribution to seed yield (Freyman *et al.*, 1973; Thurling, 1974 ; Krogman and Hobbs, 1975; Major, 1977) .

Samui *et al.* (1986) reported that there was dry matter production of 96.7 g/sq. m in Indian mustard under moisture stress which increased by 58%, 78% and 107% with application of one, two or three irrigations respectively. They concluded that irrigation might have helped better uptake and utilization of applied nutrients and thereby improved the growth. Tomer *et al.*, (1992) reported that dry matter accumulation was increased significantly up to two irrigations *viz.* preflowering and fruiting (102.87 g/plant). However, one irrigation at pre-flowering stage was at par with two irrigations.

2.2.2.4 Leaf Area Index (LAI)

LAI of Indian mustard cv. Krishna was found to increase from 0.25 to 0.30 at 30 DAS from 2.26 to 5.20 at 60 DAS and from 0.91 to 1.31 at 90 DAS over control due to application of two irrigations (Sharma and Kumar, 1989). Tomer *et al.*, (1992) also observed significant increase in the LAI of Indian mustard over control due to application of two irrigations.

2.2.3 Effect of irrigation on yield attributing characters of mustard

2.2.3.1 Number of siliqua per plant

There was a close positive correlation of seed yield with siliqua per plant and seeds per siliquae (Banerjee *et al.*, 1967) in Brassica campestris and in mustard

(Gupta and DAS, 1973). The increase in siliqua per plant was primarily due to the effect of lengthening of flowering period by irrigation (Clarke and Simpson, 1978). The number of siliqua per plant showed maximum direct and indirect effect on seed yield (Rahman *et. al.*, 1983). Samui *et. al.*, (1986) reported the average increase in siliqua number in order of 45%, 54% and 67% with one, two and three irrigations respectively over no irrigation. Sharma and Kumar (1989) reported that an increase in the frequency of irrigation significantly increased the number of siliqua per plant.

Narang and Singh (1985) reported that the plants well supplied with moisture before flower initiation were able to produce greater number of siliqua during first flush. One supplementary irrigation significantly increased the number of siliqua per plant. The respective average increase was 7.3% and 31% during 1978-79 and 1979-80 over control (Rao and Agarwal, 1985). Lal *et al.*, (1989) reported a single irrigation at flowering increased the number of siliqua per plant. Sharma (1991) found that application of two irrigation to Indian mustard *cv.* Varuna increased the number of siliqua per plant by 98.4% during 1986-87 and 121.1% during 1987-88 over control. Rana *et al.*, (1991) observed that an increase of 14.5% in the number of siliqua per plant of mustard cv. Pusa Bold due to application of irrigation as compared to no irrigation. Prakash *et al.*, (1992) reported that the number of siliqua per plant increased from 237.5 to 300.6 as the irrigation level was increased from zero to two in Indian mustard cv. Krishna. Desirable increase in number of siliqua per plant was also observed by Mathur and Tomar (1971); Mehrotra *et. at.*, (1978); Bhati and Rathore (1982); Chaniara and Damor (1982); Khan and Agarwal (1985); Parihar and Tripathy (1989) and Padmini *et al.*, (1992).

2.2.3.2 Number of seeds per siliquae

Maity *et. al.*, (1982) reported that irrigation applied during flower initiation to pod formation significantly increased seeds per siliquae and mustard yields was positively associated with the number of seeds per siliquae (Roy and Tripathy, 1985). Tomar *et. al.*, (1991) observed that seeds per siliquae were increased by 24.54, 34.36 and 48.79% by application of one, two and three irrigations at 20, 40 and 60 DAS respectively over no irrigation.

Number of seeds per siliquae of Indian mustard increased by 6.1% due to one supplemental irrigation (Rao and Agarwal, 1985). Application of two irrigations increased the number of seeds per siliquae from 10.3 to 11.9 (15.5%) during 1979-80 and from 10.6 to 12.5 (17.9%) during 1980-81 in Indian mustard as compared to the control (Samui *et. al.*, 1986). The number of seeds per siliquae were increased by irrigation (Clarke and Simpson, 1987). They had attributed this due to increase in siliqua area and greater assimilate supply. Tomer *et. al.*, (1992) reported significant increase in number of seeds per siliquae of Indian mustard with increase in irrigation levels up to two.

In contrast to this Bhan (1976) and Maharana (1986) found no significant increase in seeds per siliquae due to irrigation over control.

2.2.3.3. Test weight (1000-seed weight)

Maity *et. al.*, (1982) reported highest test weight (4.17 g) with irrigations at 3 weeks after germination + flower initiation + pod formation stage. He noticed lowest test weight of 3.97 g when the crop is rainfed. Singh and Srivastava (1986) observed an increase of test weight by 14.28% and 19.04% by application of one irrigation and two irrigations at flower bud and siliqua formation over no irrigation. Sharma and Kumar (1989) reported that increasing the irrigation level up to two increased the test weight of Indian mustard *cv.* Krishna from 4.09 g to 4.45 g as compared to the control. Sharma (1991) observed that the 1000-seed weight of Indian mustard *cv.* Varuna was more by 7.8% over control due to application of two irrigation at 30 and 60 DAS. Application of three irrigations at 20, 40 and 60 DAS increased the test weight of toria *cv.* T-9 from 2.5 g in control to 2.95 g during 1989-89 and from 2.8 g to 3.32 g during 1989-90 (Tomar *et al.*, 1991). Agarwal and Gupta (1991) reported 20% increase (4.0 to 4.8 g) in the 1000-seed weight of Indian mustard *cv.* Varuna due to irrigation. Rana *et. al.*, (1991) reported that application of irrigation to Indian mustard cv. Pusa Bold at IW : CPE ration of 0.6 increased the test weight over control by 33.5%. Singh and Saran (1993) reported that test weight was increased by 9.57% and 12.26% by application of irrigation at IW : CPE ratio of 0.2 and 0.4 respectively over no irrigation.

2.2.3.4 Seed yield

Krogman and Hobbs (1975) reported that irrigation increased the yield more than double by promoting greater plant growth, more siliqua, more seeds per siliquae and larger seeds than without irrigation. Parihar *et. al.*, (1981) observed that maximum grain yield was obtained with one irrigation three weeks after sowing which produced 4 q/ha (40%) and 4.4 q/ha (30%) higher than no irrigation in 1973-74 and 1976-77 respectively. The scheduling of irrigation based on IW : CPE ration of 0.4 recorded 19.25% and 15.90% significantly higher yield over moisture stress in 1977-78 and 1978-79 respectively (Khan and Agarwal, 1985). Irrigation had significant effect on plant growth and increased the productivity per plant resulting in increased seed yield (Singh and Srivastava, 1986).

Higher yield of mustard with two irrigations over one irrigation and no irrigation was recorded in field experiment at Mandore (1985) , Morena (1985) and Pantanagar (1985) . One supplementary irrigation to mustard increased the yield by 22.0% over no irrigation (Rao and Agarwal, 1985). Singh and Srivastava (1986) reported that two irrigation at flower bud and siliqua formation stage gave 6.1 q/ha of yield against control (Rainfed) of 3.3 q/ha while one irrigation at flower bud formation gave 4.3 q/ha. Samui *et. al.*, (1986) recorded highest mean yield of 13.3 q/ha with three irrigations which was 43.7%, 72.2% and 160.7% more over two, one and no irrigation respectively during 1979-80 and 1980-81. Prasad and Eshanulla (1988) reported that there was significant difference in seed yield due to levels of irrigation. Maximum grain yield was recorded with two irrigations applied through IW : CPE ration of 0.8 or through physiological growth stages at 30 and 60 DAS. Seed yield due to one irrigation was significantly higher over rainfed crop. Singh *et. al.*, (1989) reported that reducing the irrigations from two to one to zero reduced the seed yield by 13% and 20% respectively. Siag and Verma (1990) observed highest seed yield of Indian mustard *cv.* Varuna with three irrigations at vegetative, flowering and pod development stages. Sharma (1991) reported that seed yield of mustard *cv.* Varuna was more by 61.5% over control due to application of two irrigations at 35 and 60 DAS. With the application of three irrigations at 20, 40 and 60 DAS the seed yield of toria *cv.* T-9 was more by 243.1% over control (Tomer *et. al.*, 1991) . Prakash *et. al.*, (1992) reported an increase of 22.7% over control in the yield of mustard cv. Krishna due to application of two irrigations.

At oilseed Research Station, Berhampur, W.B., Banerjee *et. al.,* (1967) observed the effect of irrigation on toria (Brassica campestris) cv. B-54. The treatment were one irrigation, two irrigations, three irrigations and control (no irrigation). The first irrigation was given at 20 DAS and subsequent one at 20 days interval. On the basis of seed yield the difference in number of irrigations both for individual years and period as a whole were significant. On an average two irrigations gave maximum yield (740.8 kg/ha) with 49.03% increased seed yield over control.

Singh and Yusuf (1979) reported that yield response to nitrogen was dependent on moisture supply. Nitrogen gave large increase in seed yield when plots were adequately irrigated and very little increase under restricted water supply. With low levels of water more nitrogen (48 kg/ha) was required in reaching the peak yield. But with adequate water supply yield tended to be higher at lower levels of nitrogen. Lal *et. al.,* (1982) reported that seed yield of *B. Juncea cv.* Varuna were increased with the application of irrigation. Katole and Sharma (1991) reported that increase in grain yield by application of irrigation at 0.4 and 0.6 IW : CPE ration were 18.5% and 9.2% over the preceeding level of no irrigation. The highest seed yield of 18.6 q/ha was recorded with irrigation at branching + siliqua formation stage compared with control (11.8%).

Beneficial effect of irrigation on the growth and yield of mustard was also observed by different workers (Singh *et. al.,* 1971 ; Krogman and Hobbs, 1975; Bhan, 1981; Lad *et. al.,* 1982; Maity *et. al.,* 1982; Singh and Sharma , 1982; Chaniara and Damore, 1982; Narang and Singh, 1985; Dongale *et. al.,* 1990).

2.2.3.5 Oil content

Irrigation increased the fat content in the seeds and yield of oil in linseed, mustard and sunflower (Boer and Prolov, 1952). Munshi *et. al.,* (1986) reported that oil synthesis in developing seeds of *B. campestris, B. napus* var. toria was adversely affected by moisture stress. Moisture stress imposed throughout the growth period or before flowering was more detrimental to lipid deposition in B. napus var. toria seeds than when imposed after flowering. Samui *et. al.*, (1986) reported that irrigation tended to increase oil content probably due to the fact that lipid synthesis was better in optimum moisture supply. They observed lowest oil content of 30.45% under no irrigation which increased by 5%, 12% and 13% with one, two and three irrigations respectively.

Krogman and Hobbs (1975) reported that oil content of rapeseed was increased by irrigation and the oil yield was increased from 3.68 q/ha to 9.86 q/ha by enhanced irrigation. Seed oil content was highest with one irrigation at flowering stage (Bhan, 1980). Narang and Singh (1985) reported that irrigation at IW : CPE ratio of 0.6 was found conducive to boost up oil content. Tomer *et. al.*, (1991) reported in toria that irrigation applied at 20, 40 and 60 DAS gave the highest oil content (42.9 %) followed by two and one irrigation. Without irrigation the oil content was the lowest (42.45%). Irrigation at pre-flowering, seed development or both gave seed yield of 0.23,0.27 and 0.31 t/ha respectively compared with oil yield of 0.25 t/ha under rainfed condition. Sharma (1991) reported that oil content was 38.2%, 38.4% and 39.3% with 0, 1 and 2 irrigations. Ghatak *et. al.*, (1992) reported that the oil content increased with an increase in the number of irrigation compared with rainfed treatment. The interaction effect was found significant. The oil yield was increased by 71.91% and 137% with one and two irrigations compared with no irrigation. Three irrigations in combination with 80 kg N/ha gave the maximum oil yield of 501 kg/ha. Tomer *et. al.*, (1992) reported that oil yield/ha under two irrigations was higher by 25% and 69.72% over one irrigation. Increase of oil content due to irrigation was also reported by Singh and Yusuf (1979) and Stoker and Carter (1984).

2.3 Effect of Crop Geometry on Growth and Productivity of Mustard

2.3.1 Effect of crop geometry on seed yield of mustard ;

Under limited moisture supply, mustard *cv.* Varuna and KYSR were grown at 30, 40, 50 and 60 cm row spacing. Sowing at 30 - 40 cm row spacing along with application of 30 kg N/ha was found optimum and it was also recommended (Singh *et. al.*, 1978). Trials with rainfed mustard with optimum fertilizer rate showed that crops grown in rows of 30 45 and 60 cm apart gave average seed yield of 1.73, 1.97 and 1.79 t/ha respectively giving highest seed yield from 45 cm row spacing (Vir and Verma, 1981). Shinde and Borulkar (1981) conducted trials with *Brassica juncea* and they reported that plant densities of 88000, 111000, 148000 and 222000 plants/ha gave seed yields of 0.23, 0.29, 0.29 and 0.32 tonnes/ha respectively. Variety Varuna consistently out yielded Prakash and RL-18, the yields being 0.51, 0.16 and 0.17 tonnes/ha respectively. Shastry and Kumar (1981) reported that mustard *cv.* Varuna was sown at a density of 111000, 148000 and 22200 plants/ha during two years gave yield of 1.09-1.35, 1.39 - 1.41 and 1.34 - 1.35 t/ha respectively giving highest yield at a density of 148000 plants/ha.

Two mustard cv. were grown at spacing of 30 x 10, 30 x 20, 60 x 10 and 60 x 20 cm and were given 0, 40 80 and 120 kg N/ha. Maximum seed yield was obtained at spacing of 30 x 20 and 60 x 10 cm during both the years and no significant difference could be found in seed yield/plant with the plant spacing of 600 sq. cm/plant either in 30 x 20 cm or 60 x 10 cm arrangement (Singh *et. al.,* 1985b). Singh and Singh (1987) reported that row spacing of 45 cm produced markedly higher yield than 60cm spacing. Gupta (1988) conducted an experiment to study the effect of plant density on the seed yield of mustard and showed reverse trend where yield being higher with closer spacing. The seed yield with row spacing of 22.5 and 15 cm and broadcast sowing was marked by higher over wider and closer spacing of 30 and 10 cm respectively.

2.3.2 Effect of spacing on growth and yield attributes of mustard

Vir and Verma (1979) reported that dry matter production was higher in crops (*Brassica juncea*) grown in rows of 45 cm apart than those grown in rows of 30 cm or 60 cm apart under rainfed condition. Shaik and Bhargava (1984) reported that dry matter production by leaves, stems and pods increased by increasing the plant density from 15 to 22 and 44 plants/sq m and 85-90% of the total dry matter was accumulated after flowering. NAR was low and CGR was high at the higher plant density. Shaik Khader and Bhargava (1985) conducted a trial with mustard *cv.* Pusa bold. The results indicated that the total number of branches/sq m, 1000-seed weight and number of seeds/siliquae were altered by population density and these were also significantly correlated with plant density. Singh *et. al.,* (1985b) reported that, all yield components were improved significantly with the increase in plant space from 300 to 1200 sq cm/plant. However, no significant difference could be found in number of seeds/siliquae and seed yield/plant with the plant space of 600 sq cm/plant either in 30 x 20 or 60 x 10 cm arrangement. The number of siliqua/plant was more at 30 x 20 cm than at 60 x 10 cm.

Gupta (1988) reported that wider spacing of 30 x 10 cm and 22.5 x 10 cm produced more branches and siliqua/plant than closer spacing of 15 x 10 cm and 10 x 10cm and broadcast sowing in case of mustard. The later three were at par. The planting geometry of 30 x 10 cm recorded highest 1000-seed weight but the differences were marked over 15 x 10 cm only. The plant attributes like branches/plant, siliqua/plant and 1000-seed weight which are components of the seed yield recorded higher values with wider spacing but the values of these parameters on per unit area basis were higher in case of closer spacing. The advantage of closer spacing has also been observed by Patel *et. al.*, (1980) and Shaik Khader and Bhargava (1985) and Singh and Singh (1987).

Singh and Verma (1993) reported that, yield attributes like branches/plant, no of siliqua and test weight were found to be higher under wider spacings. However, the value of these parameters per unit area basis were higher in case of closer spacings. This had resulted in higher yield in closer spacing. The advantage of closer row spacing was also noted by different workers who reported that the improvement in yield attributes with wider row spacing of 60 cm did not compensate for the lower number of plants per unit area. The reduction in yield attributes under narrow spacing (higher plant density) may be ascribed to comparatively poor plant growth and development of yield attributes owing to competition for growth resources. Row spacing of 45 cm also gave significantly higher yield than that of 60 cm.

2.4. Weed Management of Mustard

Uncontrolled weeds on an average reduced the yield of Indian mustard by 33.5%. Singh *et. al.* (1989) and Tomar and Namdeo (1991) also observed a reduction in Indian mustard productivity due to weed, up to 49% and 39% respectively. Dashora *et. al.* (1990) reported that highest mustard yield was obtained with weed free control (2.23 t/ha) followed by 1.0 kg of fluchloralin (2.0 t/ha) and 0.5 kg of pendimethalin (1.94 t/ha) treatment. Though Singh *et. al.* (1989) reported pendimethalin does not increase the no. of seeds/pod, pods/plant and seed yield of *Brassica juncea* L. Weeds generally compete more with the crop in the early stage of crop growth.

2.4.1 Weed problem in mustard crop

The improved method of cultivation such as fine tilth, timely irrigation, application of manures and fertilizers provide a highly congenial environment for the rank growth of weeds in mustard field (Choudhuri and Roy, 1964) Mehrotra *et. al.*, (1972) studied the extent of weed infestation and reported that the weed spectrum in the field consisted mainly of Cyperus rotundus, Chenopodium album, Asphodelus tenuifolius, Digera arvensis, Anagallis arvensis, Spergula arvensis and Melilotus sp. Hack *et. al.*, (1966) ; Pande and Ghose (1966); Moolani and Agarwal (1967); Fedorova (1969) and Mukherjee and Chakravorty (1971) reported usual weed flora associated with crops grown in uplands during rabi season was as follows :

Grasses : *Echinochloa crus-galli, Eleusine indica, Cynodon dactylon, Imperata cylindrica, Poa anua and Setaria sp.*

Sedges : *Cyperus rotundus*

Broad leaved : *Amaranthus retoflexous, Amaranthus spinosus, Amaranthus viridis, Anagallis arvensis, Asphodelus tenuifolius, chenopodium album, Cirsium arvense, Convolvulus arvensis, Fumaria parviflora, Galinsoga parviflora, Polygonium convolvulus, Portulaca oleracea, Solanum nigram and Souchus arvensis.*

2.4.2 Effect of herbicides on mustard and other rabi crops

Mukhopadhyay and Mitra (1971) observed that pre-emergence application of TOK E-25 @ 2.0 lit *a.i.*/ha resulted in significant control of weeds and reported that the herbicide neither reduced plant population nor showed any malformation of potato plant or tuber. Stohr (1971) reported that pre-emergence application of lasso effectively controlled weeds in winter rape but depressed the crop growth. Mehrotra *et. al.* (1972)

reported that pre-emergence application of TOK E-25 @ 1.5 lit *a.i.*/ha gave a good control of weeds in mustard crop. Compared to unweeded control treatment the increase in yield due to application of TOK E-25 @ 1.5 lit *a.i.*/ha was 19.2% and the weeds were controlled to the extent of 42.6%.

Reporting the results of trials conducted at six sites during 1970-72 in oilseed rape Baart and Nalur (1972) pointed out that application of TCA @ 10-15 kg/ha at seeding gave a good control of volunteer winter barley but caused a slight crop injury. They also noted that a tank mixture of TCA plus "Gesatop-50" 12.0 to 5 kg/ha applied at seeding gave fair to good control of all major weeds and despite some initial crop injury, rape yielded higher than that of the control. Harman *et. al.*, (1974) observed that pre-emergence application of alachlor in combination with chlorbromiron or Metribuzin gave best control of weeds in potato fields and highest yield of tubers. Wilson (1974) obtained excellent control of weeds in potato with the application of Alachlor @ 2 kg/ha as a pre-emergence spray. Soundara Rajan *et. al.*, (1974) reported Basalin at 2.5 t/ha as presowing application was found to be as effective as one hand weeding in the control of weeds and increasing pod yield of groundnut.

Ghosh and Mukhopadhyay (1981) reported that, spraying of TOK E-25 @ 6 lit/ha with 500 lit of water one day after sowing (pre-emergence) gave better result in case of mustard than spraying one month after sowing (post-emergence). Basalin 1.5 lit/ha also gave good result when the application of it was done as pre-emergence (one day after sowing). Same results were also obtained by them in case of sesame crop.

Saha *et. al.* (1990) reported, preplant soil incorporation of fluchloralin (Basalin 45 EC) at 0.75 kg a.i./ha + AC - 263, 499 (percuit 5 WCC) at 0.075 kg a.i./ha at early post emergence not only reduced the crop-weed competition significantly but also recorded the highest pod yield (14.8 q/ha) and higher additional income (Rs.5,236/- per ha) over unweeded control in case of rainfed groundnut. Karmakar *et. al.*, (1994) observed, classic at 12 g/ha gave the good yield of groundnut which was at par with hand weeding twice (20 and 30 DAS).

2.4.3 Effect of pendimethalin (Stomp) and linuron (Afalon) on weed management of crops

Adamczewski *et. al.*, (1987) observed, Stomp 30 EC (Pendimethalin) gave satisfactory weed control of pea when applied as pre-sowing. Excellent grass weed control was also achieved with pendimethalin @ 2.4 kg/ha (as Stomp) and herbicide gave higher yield than the unweeded control and yield comparable to the hand weeded control (Mohamed, 1988). Ibrahim *et. al.*, (1988) reported that, in a pre-emergence herbicide evaluation in irrigated sunflower *cv.* Miak, pendimethalin (Stomp) at 2.04 kg/ha in tank mixtures with terbutryn (Igran) at 2.88 kg or linuron (Afalon) at 1.2 kg gave excellent control of the annual broad leaved weeds and grasses present and resulted in yields higher than hand hoeing and the other treatments. They also reported 2.4 kg pendimetahlin (Stomp) per ha in combination with either 1.14 kg linuron + monolinuron (Afalon) or 2.88 kg terbutryn (Igran) provided the best weed control (more than 80% better than the unweeded control) and yield of safflower (46.7% and 32.3% more than hand hoeing respectively). Dubey *et. al.*, (1988) also observed the weed control capacity of pendimethalin (Stomp) when it applied @ 1 kg a.i./ha. Bond and Walker (1989) studied the herbicide activity and persistence under low level polyethylene cover and reported that, linuron + trifluralin and linuron + pendimethalin gave good weed control in both covered and uncovered plots. Linuron was not very effective against *Veronica perasic* and *Fumaria officinalis* both under polyethylene and in the open. Pre-emergence sprays of linuron and pendimethalin achieved good weed control with little or no crop damage in case of sunflower (Dixon *et. al.*, (1989). Afalon (linuron, 50%) at 2 kg applied 2-3 weeks after sowing provided good control of broad leaved weeds and Echinochloa crusgalli without affecting the development and yield of crops (Dobrazanski and Palczynski, 1989).

2.5 Summary and Scope of the Work

The above literature indicates that irrigation and nitrogen plays a vital role in influencing the growth and yield of mustard. Hence, optimisation of level of irrigation and method of nitrogen application is essential not only to increase the yield of this crop but also to improve the quality of the produce. In comparison to nitrogen, limited works have been done on the plant density and weed management which also play a vital role in the optimisation of yield of mustard.

In Gangetic plains of West Bengal, climatic condition favours mustard cultivation in intensive cropping. There is limited information available on the low cost package of practices of mustard for the farmer of this region. Works on this line are very meagre particularly under rainfed condition where cultivation of this crop is gaining ground by using the residual soil moisture of the previous Kharif season. Hence, a study in this nature is required to improve the productivity of mustard under irrigated as well as rainfed condition.

MATERIALS AND METHODS

The field experiments were conducted at the District Seed Farm of Bidhan Chandra Krishi Viswavidyalaya at Kalayani, Nadia, West Bengal during the rabi season of 1995-96 and 1996-97 to study the growth and productivity of mustard under different management practices. This farm is situated at 23.5^0 N latitude, 89^0 E longitude and at an attitude of 9.75 meter above sea level.

3.1 Climatic Condition

The place has subtropical humid climate. The average annual rainfall is 1450.00 mm mostly precipitated during June to September and the mean monthly temperature range from 17.6^{0}C to 30.8^{0}C. Broadly, the seasons are classified as (i) the cool season (November to February), (ii) dry season (March to May) and (iii) wet season (June to October). The meteorological data pertaining to the duration of experimentation are furnished in table 3.1.

3.1.1 Temperature

The average monthly maximum and minimum temperatures measured by maximum and minimum thermometers during October to March varied from 25.1 to 38.4^{0}C and 12.2 to 23.7^{0}C in 1995-96 and 24.38 to 32.7^{0}C and 10.71 to 22.39^{0}C in 1996-97 respectively ; while the long term average maximum and minimum temperatures during October to March were 32.9 and 9.9^{0}C respectively. The fluctuation of maximum and minimum temperatures during the period of experimentation were also shown in fig. 3.1.

3.1.2 Rainfall

Rainfall was measured through automatic rain gauge. The cumulative rainfall during the cropping seasons from October, 1995 to March, 1996 was 165.02 mm and October, 1996 to March, 1997 was 310.74 mm. The cumulative rainfall recorded during 1995-96 was below the normal cumulative rainfall (174.0 mm) for the same period of

Table 3.1 : Monthly meteorological data recorded during the years of experimentation

Month	Total rainfall (mm)			Temperature (°C)						Relative humidity (%)					
				Maximum			Minimum			Maximum			Minimum		
	LTA	1995-96	1996-97	LTA	1995-96	1996-97	LTA	1995-96	1996-97	LTA	1995-96	1996-97	LTA	1995-96	1996-97
October	114.7	3.02	133.90	30.2	32.0	31.50	23.8	23.7	22.39	90.0	94.9	95.45	65.0	68.4	62.40
November	17.2	28.40	5.70	29.4	28.4	29.52	16.1	18.4	16.73	86.0	94.9	96.03	47.0	55.1	49.23
December	3.2	26.50	0.00	25.9	26.4	26.00	11.2	12.6	11.36	87.0	96.8	94.64	38.0	47.1	44.03
January	7.6	8.80	24.30	25.4	25.1	24.38	9.9	12.2	10.71	89.0	96.3	95.19	41.0	52.8	47.45
February	7.9	64.60	35.54	27.8	27.9	27.00	13.2	14.6	15.01	86.1	95.6	96.00	49.5	50.7	46.70
March	23.4	33.70	111.30	32.9	33.5	32.70	19.9	21.8	21.20	82.7	93.2	95.80	37.0	42.0	79.00

Note : LTA = Long Term Average (monthly mean of preceeding 20 years)

Source : Agricultural meteorological observatory, Kalyani, Nadia, W. B.

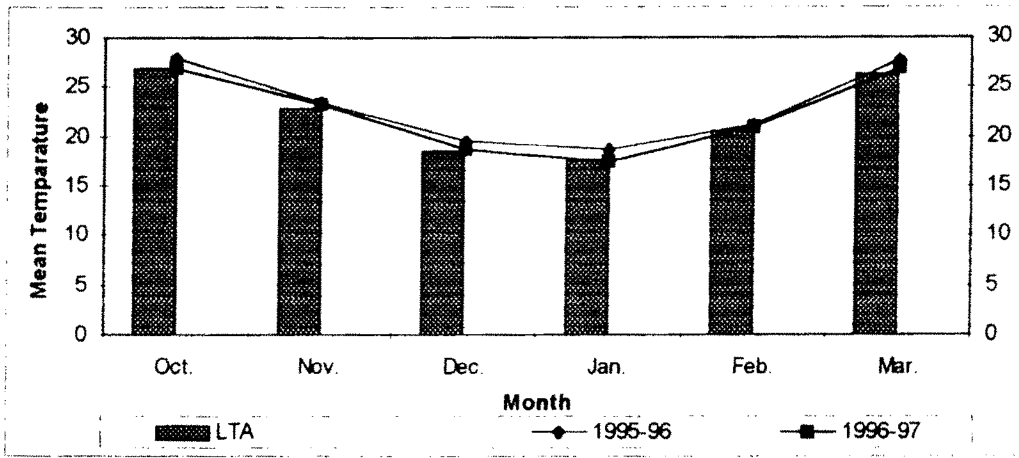

Fig. 3.1 **Mean Temparature in °C** during the period of experimentation

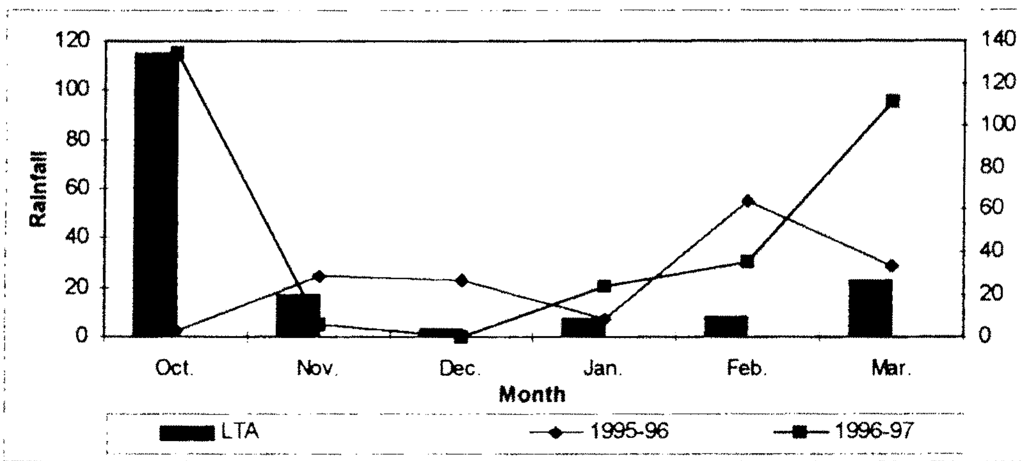

Fig. 3.2 **Rainfall (mm) distribution** during the period of experimentation

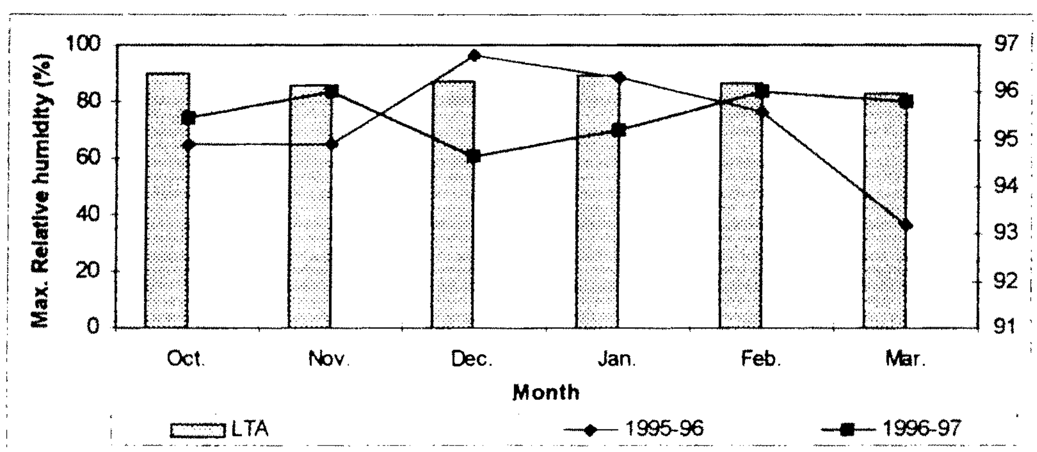

Fig. 3.3 **Maximum Relative humidity(%)** during the period of experimentation

this area estimated over the last 20 years. But the rainfall received during the crop season of 1996-97 was much higher than that recorded during the previous crop season (Table 3.1 and Fig. 3.2).

3.1.3 Relative humidity

The maximum and minimum relative humidity measured by 'Psycrometer' during the cropping season (October to March) were averaged 95.28% and 52.68% in 1995-96 and 95.8% and 49.0% in 1996-97. The maximum and minimum relative humidity during the cropping periods were higher than normal. The monthly distribution of maximum and minimum relative humidity during the cropping season of 1995-96 and 1996-97 are presented in table 3.1.

3.2 Experimental Soils

The experiment was conducted in a medium land with good irrigation and drainage facility. The soil of the experimental area was sandy clay loam in texture having moderate water holding capacity. The soil was medium in fertility with neutral in reaction (pH 7.28) representing the characteristics of alluvial soil.

Composite soil samples of the experimental field were collected with soil augur for physico-chemical analysis. The physico-chemical properties of the soil have been summarised in the table 3.2.

Table 3.2 Physico-chemical properties of the experimental soil

Soils character	Content	method followed
Sand	36.2 %	International Pipette method (Piper, 1966)
Silt	24.2 %	
Clay	37.8 %	
Total N	0.06 %	Modified kjeldahl method (Jackson, 1967)
Organic carbon	0.59 %	Walkley and Black method (Piper, 1966)
Available P (kg P_2O_5 ha^{-1})	20 kg ha^{-1}	Olsen's method (Jackson, 1967)
Available K (kg K_2O ha^{-1})	160 kg ha^{-1}	Flame photometer method (Jackson, 1967)
Soil pH	7.28	Backman's pH meter in 1:2.5 soil water suspension (Jackson, 1967)

3.3 Cropping History of the Experimental Field

The cropping history of the experimental field for the last three years, prior to the present experimentation was given in the table 3.3.

Table 3.3 : Cropping history of the experimental field

Year	Seasons		
	Pre Kharif	Kharif	Rabi
1992 - 93	HYV rice	HYV rice	Rapeseed
1993 - 94	-	HYV rice	Brinjal
1994 - 95	Jute	HYV rice	Potato
1995 - 96	-	HYV rice	

3.4 Experimental Details

Two experiments were conducted to study the growth and productivity of mustard under different management practice and to calculate the economics of mustard cultivation at those management prectices.

3.4.1 Experimental design and layout

3.4.1.1 Experiment No. 1

This experiment was laid out in Factorial Randomised Block Design (Fig. 3.4) with two irrigation, three methods of nitrogen application and two weed managing treatment levels. The experiment was conducted in 4m X 5m plots with three replications during rabi seasons of 1995-96 and 1996-97 with the mustard variety B-85 (Sita). The details of treatments and their combination are given below :

3.4.1.1.1 Treatment details

A) Irrigation levels

i) I_1 = One irrigation at branching stage (30 - 35 DAS)

ii) I_2 = Two irrigations : one at branching stage (30 - 35 DAS) and another at siliqua formation stage (50 - 55 DAS)

B) Method of nitrogen application

i) M_1 = 80 kg N/ha supplied as basal

ii) M_2 = 80 kg N/ha supplied half (40kg/ha) as basal and remaining half (40kg/ha) as top dressing before 1st irrigation *i.e.*, at 30 - 35 DAS

iii) M_3 = 40 kg N/ha supplied as foliar spray (2% urea solution) at 15, 30, 45 and 60 DAS @ 5, 10, 15 and 10 kg N/ha respectively.

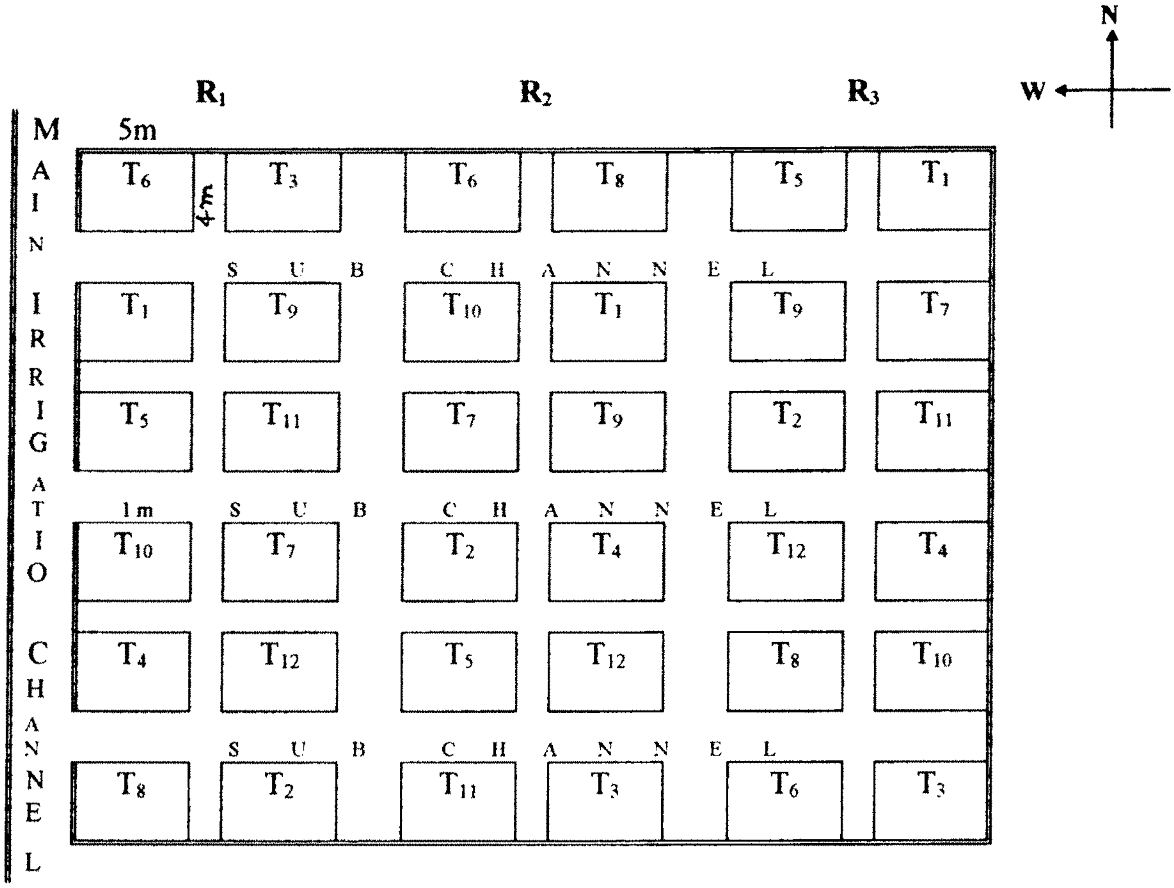

Fig. 3.4 Layout of the irrigated experiment

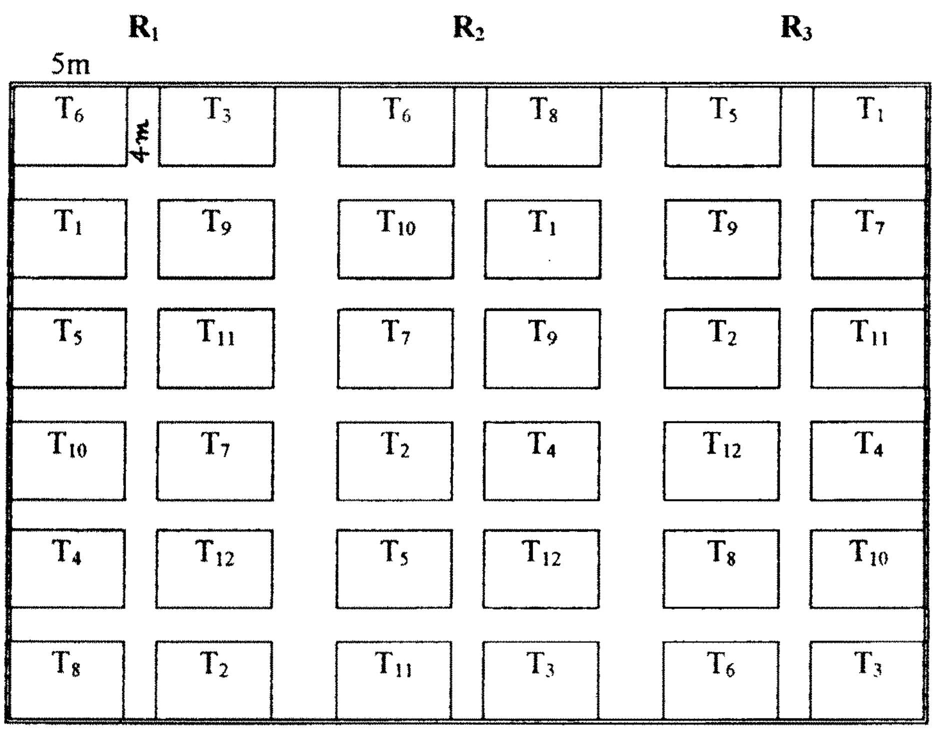

Fig. 3.5 Layout of the rainfed experiment

C) Weed management

i) W_1 = Afalon (linuron) 50 WP @ 0.750 kg a.i./ha

ii) W_2 = Stomp (pendimethalin) 30 EC @ 1.0 kg a.i./ha.

3.4.1.1.2 Treatment combinations :

$T_1 = I_1 M_1 W_1$	$T_7 = I_2 M_1 W_1$
$T_2 = I_1 M_1 W_2$	$T_8 = I_2 M_1 W_2$
$T_3 = I_1 M_2 W_1$	$T_9 = I_2 M_2 W_1$
$T_4 = I_1 M_2 W_2$	$T_{10} = I_2 M_2 W_2$
$T_5 = I_1 M_3 W_1$	$T_{11} = I_2 M_3 W_1$
$T_6 = I_1 M_3 W_2$	$T_{12} = I_2 M_3 W_2$

3.4.1.2 Experiment No. 2 (Rainfed mustard)

This experiment was laid out in Randomised Block Design (Fig. 3.5) with two spacing, three methods of nitrogen application and two weed managing treatment levels. The experiment was conducted in 4m X 5m plots with three replications during rabi season of 1995-96 and 1996-97 with mustard variety B-85 (Sita).

3.4.1.2.1 Treatment details

A) Spacing level

i) S_1 = 30 cm x 15 cm

ii) S_2 = 25 cm x 15 cm

B) Method of nitrogen application

i) M'_1 = 60 kg N/ha supplied as basal.

ii) M'_2 = 60 kg N/ha supplied half (30kg/ha) as basal and remaining half through foliar spray (2% urea solution) at 15, 30 and 45 DAS @ 5, 15 and 10 kg N/ha respectively.

iii) M'_3 = 30 kg N/ha supplied through foliar spray (2% urea solution) at 15, 30 and 45 DAS @ 5, 15 and 10 kg N/ha respectively.

C) Weed management

i) W'_1 = Afalon (linuron) 50 WP @ 0.750 kg a.i./ha

ii) W'_2 = Stomp (pendimethalin) 30 EC @ 1.0 kg at /ha.

3.4.1.2.2 Treatment combinations

$T_1 = S_1\, M'_1\, W'_1$	$T_7 = S_2\, M'_1\, W'_1$
$T_2 = S_1\, M'_1\, W'_2$	$T_8 = S_2\, M'_1\, W'_2$
$T_3 = S_1\, M'_2\, W'_1$	$T_9 = S_2\, M'_2\, W'_1$
$T_4 = S_1\, M'_2\, W'_2$	$T_{10} = S_2\, M'_2\, W'_2$
$T_5 = S_1\, M'_3\, W'_1$	$T_{11} = S_2\, M'_3\, W'_1$
$T_6 = S_1\, M'_3\, W'_2$	$T_{12} = S_2\, M'_3\, W'_2$

3.4.2 Crop variety

Mustard variety B-85 (Sita) was used as a test crop. This variety matures in 90 - 100 days. Plants are tall and well branched. Seeds are medium sized, round or oval, reddish brown in colour with an average oil content of 38%. Its yield potential is 12 - 15 quintals/ha.

3.4.3 Herbicides

Two herbicides namely, Linuron and Pendimethalin in the form of Afalon 50 WP and Stomp 30 EC respectively were used in this studies.

Linuron is a substituted urea herbicides, the chemical name of it is 3-(3, 4-dichlorophenoxyl)-1-methoxy-1-methyl urea. It killed weeds mainly through inhibition of hill reaction of photosynthesis.

Pendimethalin is a dinitro anilyn group of herbiscide, the chemical name of it is N-(1-ethylpropyl) 3,4-dimethyl-2, 6-dinitro anilyn. It checks root and shoot growth, affects RNA, DNA, protein and amino acid synthesis of weeds.

3.5 Agronomic Practices

3.5.1 Land preparation

In each year, fifteen days before commencement of experiment, the land was ploughed cross wise by a tractor drawn disc harrow. Then one deep ploughing was given by a tractor drawn cultivator followed by laddering to break the clods. Two ploughings were given by a power tiller to obtain well pulverised soil. Finally, the land was levelled through laddering drawn by bullocks.

3.5.2 Application of fertilizers

Fertilizers were applied plot-wise as per the treatment combinations. In case of foliar application of nitrogen, 2% urea solution is used as spray material.

3.5.3 Treatment of seeds

Seed treatment was done by fungicide (Bavistin) @ 2 gm/kg of seeds. It was done by placing proper quantity of fungicide and seed in a bucket and mixing of seeds with the fungicide was done by rotating the bucket slowly. While rotating the bucket, little water was sprinkled so that the surface of each seed gets a complete coating of fungicide. Then the seeds were taken out from the bucket and spread over a polythene sheet under the shade for 30 minutes. The above operation started one hour before sowing.

3.5.4 Sowing

Sowing was done in line with the help of duck foot tyne by opening a shallow furrow (2.5 to 3.0 cm deep). In case of irrigated crop sowing was done at a row distance of 35 cm with a seed rate of 5 kg/ha. In case of rainfed crop the spacing was maintained according to the treatment combinations. In both the cases mustard variety Sita (B-85) was sown in north - south direction.

3.5.5 Intercultural operation

Two thinings were done at 15 and 32 DAS to maintain desired plant to plant spacing according to the treatment combination. The weeds of the experimental plots were effectively managed by pre-emergence application of two herbicides i.e., afalon (Linuron) 50 WP @ 0.750 kg a.i./ha and stomp (Pendimethalin) 30 EC @ kg a.i.,/ha.

3.5.6 Irrigation

Irrigation, one of the experimental factors in the present study was applied according to the treatment combination described earlier.

3.5.7 Plant protection measure

The crop was affected by mustard aphid (*Lipaphis erysimi*) during 1995-96 but it was free from infestation during 1996-97. The mustard aphid was controlled by spraying metasystox 25 EC at 0.05%.

3.5.8 Harvesting and threshing

The matured mustard plants were harvested at the ground level from net plot discarding the border and were subsequently threshed after sun drying.

3.6 Methods of Recording Observation

The observations for the various growth attributes and yield component at different stages of crop growth were taken from the area ear-marked for destructive sampling.

3.6.1 Growth attributes

The effect of different treatments on the various growth characters and yield contributing factors on the crop were studied as below.

3.6.1.1 Dry matter (DM) accumulation

Leaf and stem samples were taken at an interval of 20 days upto maturity beginning with 20 DAS. At each sampling, one meter long row was randomly selected. The plants were harvested at the ground level. Leaves and stems were separated for their individual dry weight determinations. The samples were then thoroughly washed to remove all the soil particles and other materials adhered to it. These samples were then dried in a hot air oven at 65^0C till constant weight was recorded.

3.6.1.2 Determinations of leaf area index (LAI)

The representative green leaf laminae were taken randomly from destructive samples and 30 cored pieces were made with a leaf corer of known diameter. Those cored leaf pieces were then dried in hot air oven at 80^0C for 48 hours till constant weights were obtained and weight were taken with an electrical balance. The ratio of leaf area weight of these cored pieces were used to determine the leaf area indices (Kemp, 1960). Since, LAI is the area of leaf surface per unit of land area (Watson, 1952) the leaf area index was obtained by multiplying the ratio of area/weight with dry weight of green leaves produced per square meter of land surface.

3.6.1.3 Crop growth rate (CGR)

It may be defined as the gain in weight of a community of plants in a unit area of land in a unit time. Mean values over a period of time was determined by using the following formula :

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, W_1 and W_2 are the total dry weight of plants at two different times t_1 and t_2 respectively. The unit used was ; $g/m^2/day$ (Watson, 1952).

3.6.1.4 Net assimilation rate (NAR)

Net assimilation rate was determined by using the following formula given by Watson (1952).

$$NAR = \frac{W_2 - W_1}{t_2 - t_1} / \frac{L_2 - L_1}{Log_e L_2 - Log_e L_1} \text{ (g/m}^2\text{/day)}$$

Where, W_2 and W_1 are the final and initial dry weight of all plant parts per unit area at the time t_2 and t_1 respectively and L_2 and L_1 are the final and initial leaf area indices at respective times.

3.6.2 Yield components

3.6.2.1 Height of the plant

The height of ten plants selected at random from each plot were recorded from the ground level to the tip of the plant at 80 DAS. The heights were measured and the average of the plant height was calculated for each plot.

3.6.2.2 Number of primary and secondary branches per plant

Total number of primary and secondary branches were counted from ten randomly selected plants of each plot at the time of harvest and then the average was calculated.

3.6.2.3 Number of siliqua/plant

Total number of filled siliqua per plant were recorded from ten randomly selected plants of each plot at harvest.

3.6.2.4 Number of seeds/siliquae

Twenty randomly selected filled siliqua from each plot were taken, threshed individually and seeds were counted.

3.6.2.5 Test weight of seed

From the threshed product of each plot, 1000 seeds were collected, air dried and their respective weights (in gm) were recorded.

3.6.3 Post harvest observation

For post harvest observations net plot size was harvested discarding border lines to avoid border effects.

3.6.3.1 Seed yield

After harvesting of matured plants from the net plot, discarding border rows, these were dried in the sun and subsequently threshed. Then the weight of seed was taken and converted to kg/ha.

3.6.3.2 Stover yield

After threshing, weight of the dried plant recorded and converted to kg/ha.

3.6.3.3 Determination of oil percentage

The percentage of oil in mustard seeds were estimated by adopting Soxhlet Ether Extraction method : 5 g seed sample for each treatment combination was used for the purpose.

3.6.3.4 Oil yield

Oil yield/hactre for each treatment was computed by multiplying seed yield per hactre with the oil percentage of respective treatment and recorded separately.

3.7 Harvest Index

The harvest index (H.I.) was obtained by using the following formula :

$$\text{H.I. (\%)} = \frac{\text{Economic yield}}{\text{Biological yield}} \times 100$$

The economic yield is the seed yield, where as the biological yield represents both seed and haulm yields.

3.8 Chemical Analysis of Soil Samples

Presowing and post harvest soil samples from each experimental plot was collected at 15 cm depth with the help of soil augur and samples from three replications were mixed together treatment wise in each year. The samples were then thoroughly dried in shade, pulverised to pass through 0.2 mm sieve and kept for chemical analysis. Analysis were done by the procedures as out lined by Jackson (1973).

3.8.1 Soil pH

The pH of the experimental soil was determined with pH meter by using soil water suspension (1:2.5).

3.8.2 Organic carbon

The organic carbon content in soil samples were determined by volumetric redox titration method developed by walkley and Black (Jackson, 1973).

3.8.3 Total nitrogen

Total nitrogen content in soil samples were determined by modified macro Kjeldahl method (Jackson, 1973).

3.8.4 Available phosphorus

The available phosphorus content in soil sample were estimated by Olsen's method. The colour was developed with freshly prepared stanneus chloride in presence of chloromolybdic acid solution. The intensity of colour was determined with the help of a spectro colorimeter at 660 mm wave length (Jackson, 1973).

3.8.5 Available potassium

The available potassium content of the soil sample were determined by Flame photometer (Jackson, 1973). Neutral normal ammonium acetate was used as extractant of soil K.

3.9 Calculation of Nutrient Uptake

The nutrient uptake of the major elements, N, P and K for all the crops in the sequence were worked out for two consecutive years on dry weight baiss by multiplying the dry matter yield of each crop with their corresponding content of nutrient element.

3.10 Statistical Analysis

The statistical analysis of data was calculated by the analysis of variance table (Panse and Sukatme, 1989 ; Gomez and Gomez, 1984) used in the factorial Randomised Block Design. The tables formulated by Fisher and Yates (1974) were consulted for the purpose of comparison of F-Values and for determination of critical difference at probability level of 0.05. The correlation co efficient between different measurable characters were also worked out.

3.11 Economic Analysis

Cost of various inputs and crop management practice in producing the crops and the price of mustard seeds were estimated as per available market information. Cost of cultivation, gross and net return of the crop with various treatments were then calculated.

CHAPTER IV

RESULTS

In this chapter the results of the experiment conducted to study the growth and productivity of mustard under different management practices have been presented and discussed.

4.1 Experiment in irrigated soil :

Studies on irrigation, method of nitrogen application and weed management on growth and productivity of mustard.

4.1.1 Variation in Growth Attributes

Observations on various growth attributes such as leaf area index, crop growth rate and net assimilation rate recorded at various growth stages during the two years of study have been presented and summerised below.

4.1.1.1 Leaf area index (LAI)

Leaf area index of any crop is an important criteria that influences the productivity of the crop. It determines the photosynthetic capacity of the crop (Littleton *et al.*, 1979; Monteith and Elson, 1983; Squire, 1990). Observation on leaf area index recorded at 20, 40, 60 and 80 DAS during the two years of experimentation had been statistically analysed and presented in table 4.1. The leaf area index of the crop increased steadily upto 60 DAS, then it declined rapidly as the crop progressed towards its maturity. The highest value of leaf area index (5.74) was recorded at 60 DAS of the crop when nitrogen was given through second method of application. The lowest value in leaf area index at all the growth stages were recorded from the crop which has received only one irrigation.

The results clearly indicate that mustard requires adequate irrigation for its better foliage production which in turn helps in improving growth and productivity of the crop. The leaf area indices recorded at all the growth stages (20, 40, 60 and 80 DAS)

Table 4.1 Effect of irrigation, method of N application and weed management on leaf area index (LAI) at different stages

Treatment	LAI at 20 DAS			LAI at 40 DAS			LAI at 60 DAS			LAI at 80 DAS		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Irrigation level												
I_1	0.22	0.23	0.22	1.30	1.33	1.31	4.95	5.04	5.00	2.55	2.61	2.58
I_2	0.27	0.28	0.28	1.47	1.52	1.49	5.51	5.63	5.57	2.84	2.98	2.91
S.Em (±)	0.003	0.002	0.002	0.018	0.011	0.01	0.022	0.016	0.010	0.014	0.040	0.020
C.D. at 5%	0.010	0.007	0.006	0.052	0.033	0.030	0.065	0.046	0.039	0.041	0.119	0.062
Method of N application												
M_1	0.23	0.24	0.23	1.31	1.26	1.28	4.87	4.92	4.90	2.49	2.62	2.56
M_2	0.27	0.29	0.28	1.58	1.67	1.62	5.68	5.81	5.74	2.96	3.01	2.98
M_3	0.23	0.24	0.24	1.27	1.34	1.30	5.15	5.28	5.21	2.64	2.76	2.70
S.Em (±)	0.004	0.003	0.002	0.022	0.013	0.010	0.027	0.019	0.010	0.017	0.070	0.020
C.D. at 5%	0.012	0.008	0.007	0.064	0.040	0.037	0.080	0.057	0.048	0.051	0.146	0.075
Weed management												
W_1	0.22	0.23	0.22	1.26	1.30	1.28	5.04	5.19	5.12	2.60	2.72	2.66
W_2	0.27	0.28	0.27	1.51	1.54	1.52	5.42	5.49	5.45	2.79	2.87	2.83
S.Em (±)	0.003	0.002	0.002	0.018	0.011	0.010	0.022	0.016	0.010	0.014	0.040	0.020
C.D. at 5%	0.010	0.007	0.006	0.058	0.033	0.030	0.065	0.046	0.039	0.041	0.119	0.062
C.V. %	12.12	13.84	11.05	12.49	10.35	12.55	10.81	11.27	11.56	12.23	10.17	13.71

during both the years increased significantly due to levels of irrigation. The LAI of 60 DAS was influenced significantly through two irrigations over one irrigation (Fig. 4.1).

Among the different methods of nitrogen application highest LAI values was obtained with the application of 80 Kg/ha of N, supplied half as basal and the remaining half as top dressing before 1st irrigation in all the growth stages during both the years as well as in pooled. The results clearly indicate that mustard required irrigation and optimum nitrogenous fertilizer through appropriate method of application for its better foliage production.

Pendimethalin shows its effectivity over linuron as an weed managing treatment on increasing the LAI values of the crop in all the growth stage during both the years of experimentation as well as in pooled. So, from the data it reveals that by managing the weeds effectively in the early growth stages, pendimethalin helps in better foliage production of mustard which should help in increasing the photosynthates and ultimately the higher yield.

Interaction effect of levels of irrigation, methods of N application and weed management treatments in improving the LAI values of mustard at 20 and 40 DAS were found not significant but these values were significant at 60 DAS and 80 DAS in both the years of experimentation as well as in pooled data (Appendix table 1.3, 1.4, 1.5 and 1.6).

4.1.1.2 Crop growth rate (CGR)

The crop growth rates estimated during the periods of 20-40 DAS, 40-60 DAS and 60-80 DAS of the crop during the two years of experimentation had been statistically analysed and presented in table 4.2. It was observed that crop growth rate gradually increased upto the siliqua development period during both the years.

The results showed that two irrigations given at branching and siliqua formation stage increased the crop growth rates significantly over one irrigation given only at branching stage at all the growth stages (20-40 DAS, 40-60 DAS and 60-80 DAS) during both the years under study as well as in pooled data. However, the differences

Table 4.2 Effect of irrigation, method of N application and weed management on crop growth rate (g m^{-2} day^{-1}) at different stages

Treatment	CGR (20-40 DAS)			CGR (40-60 DAS)			CGR (60-80 DAS)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Irrigation Level									
I_1	9.63	9.73	9.68	13.76	15.99	14.88	18.66	15.86	17.23
I_2	10.71	10.66	10.69	14.54	17.67	16.10	21.66	20.39	21.03
S.Em (±)	0.05	0.05	0.03	0.03	0.04	0.02	0.06	0.09	0.05
C.D. at 5%	0.17	0.02	0.11	0.09	0.13	0.08	0.18	0.27	0.16
Method of N application									
M_1	9.75	9.61	9.68	13.00	15.59	14.29	18.97	15.77	17.37
M_2	11.37	11.37	11.37	15.75	18.25	17.00	21.77	20.86	21.32
M_3	9.40	9.62	9.51	13.71	16.65	15.18	19.65	17.75	18.70
S.Em (±)	0.07	0.06	0.04	0.04	0.05	0.03	0.07	0.11	0.06
C.D. at 5%	0.21	0.18	0.13	0.11	0.16	0.10	0.22	0.33	0.19
Weed management									
W_1	9.28	9.43	9.36	13.41	16.35	14.88	19.04	16.38	17.71
W_2	11.06	10.96	11.01	14.89	17.31	16.10	21.22	19.87	21.55
S.Em (±)	0.09	0.05	0.03	0.03	0.04	0.02	0.06	0.09	0.05
C.D. at 5%	0.17	0.15	0.11	0.09	0.13	0.08	0.18	0.27	0.16
C.V. %	12.39	12.07	12.23	10.88	12.11	11.03	10.28	12.16	11.73

Table 4.3 Interaction effects between irrigation, method of N application and weed management on crop growth rate (g m^{-2} day^{-1}) at 60 - 80 DAS

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	16.63	19.41	18.11	**18.05**	11.67	16.38	14.96	**14.33**	14.15	17.89	16.53	**16.19**
	W_2	17.84	20.02	19.61	**19.15**	13.68	20.87	17.64	**17.39**	15.76	20.44	18.62	**18.27**
	Mean	**18.78**	**21.87**	**19.44**	**20.03**	**16.21**	**21.62**	**17.48**	**18.43**	**17.49**	**21.74**	**18.46**	**19.23**
I_2	W_1	18.78	21.87	19.44	**20.03**	16.21	21.62	17.48	**18.43**	17.49	21.74	18.46	**19.23**
	W_2	22.64	25.79	21.46	**23.29**	21.54	24.60	20.94	**22.36**	22.09	25.19	21.20	**22.82**
	Mean	**20.71**	**23.83**	**20.45**	**21.66**	**18.87**	**23.11**	**19.21**	**20.39**	**19.79**	**23.47**	**19.83**	**21.03**
($I_1 + I_2$)	W_1	17.70	20.64	18.77	19.04	13.94	19.00	16.22	**16.38**	15.82	19.82	17.49	**17.71**
	W_2	20.24	20.90	20.53	**21.22**	17.61	22.73	19.29	**19.87**	18.92	22.82	19.91	**20.55**
	Mean	**18.97**	**21.77**	**19.65**	**20.13**	**15.77**	**20.86**	**17.75**	**18.13**	**17.37**	**21.32**	**18.70**	**19.13**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.060	0.177	0.092	0.270	0.055	0.158
M	0.074	0.217	0.113	0.331	0.067	0.194
I x M	0.104	0.307	0.160	0.469	0.095	0.274
W	0.060	0.177	0.092	0.270	0.055	0.158
I x W	0.085	0.251	0.130	0.383	0.078	0.024
M x W	0.104	0.307	0.160	NS	0.095	0.274
I x M x W	0.148	0.434	0.226	0.663	0.135	0.388
CV %	11.28		12.16		11.73	

in CGR values between one irrigation and two irrigations receiving crops were found significant during all the growth stages of the crop in both the years.

During all the growth stages the highest CGR values were obtained with the application of higher dose of N (80 Kg/ha), supplied half as basal and remaining half as top dressing before 1st irrigation. The differences in CGR values among the crops received N in different methods of application were also found significant.

The data clearly indicates that pendimethalin significantly shows its effectivity over linuron on influencing the CGR values of the crop through managing the weeds effectively in all the growth stages of the crop during both the years as well as in pooled (Fig. 4.2).

The interaction effects between levels of irrigation and method of N application; weed management and method of Nitrogen application; irrigation method of N application and weed management on influencing the CGR values of the plants in different stages of the crop growth were found to be significant during both the years of experimentation (table 4.3 and appendix table 1.7 and 1.8) except the value of interactive effect between weed management and method of N application was found not significant in 1996-97. At 60-80 DAS stage the higher CGR values were obtained when the crop has received two irrigations and pendimethalin as weed managing treatment and the N (80 Kg/ha) was applied half as basal and remaining half as top dressing before 1st irrigation.

4.1.1.3 Net assimilation rate (NAR)

The net assimilation rates estimated during the periods of 20-40 DAS, 40-60 DAS and 60-80 DAS of the crop during the two years of experimentation had been statistically analysed and presented in table 4.4.

The results showed that two irrigation given at branching and siliqua formation stage increased the net assimilation rates significantly over one irrigation given only at branching stage at all the growth stages (20-40 DAS, 40-60 DAS and 60-80 DAS) during both the years under study as well as in pooled data. Two irrigations proved its

Table 4.4 Effect of irrigation, method of N application and weed management on net assimilation rate (g m^{-2} day^{-1}) at different stages

Treatment	NAR (20-40 DAS)			NAR (40-60 DAS)			NAR (60-80 DAS)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Irrigation Level									
I_1	15.86	15.54	15.70	5.06	5.75	5.41	5.16	4.26	4.71
I_2	15.20	14.47	14.83	4.75	5.61	5.18	5.36	4.88	5.12
S.Em (±)	0.16	0.07	0.08	0.03	0.02	0.02	0.01	0.04	0.02
C.D. at 5%	0.47	0.23	0.26	0.10	0.09	0.07	0.05	0.12	0.06
Method of N application									
M_1	15.96	15.74	15.85	4.86	5.82	5.34	5.32	4.28	4.80
M_2	15.28	14.40	14.84	4.91	5.45	5.18	5.22	4.87	5.04
M_3	15.35	14.88	15.11	4.95	5.78	5.37	5.23	4.56	4.90
S.Em (±)	0.19	0.09	0.10	0.04	0.03	0.02	0.02	0.04	0.02
C.D. at 5%	0.58	0.23	0.31	0.18	0.11	0.08	0.07	0.14	0.08
Weed management									
W_1	15.53	15.20	15.36	4.91	5.81	5.36	5.14	4.25	4.70
W_2	15.53	14.81	15.17	4.90	5.55	5.22	5.37	4.89	5.14
S.Em (±)	0.16	0.07	0.08	0.03	0.02	0.02	0.01	0.04	0.02
C.D. at 5%	0.12	0.10	0.11	0.09	0.09	0.07	0.05	0.12	0.06
C.V. %	12.39	12.19	13.50	12.96	12.23	12.57	11.50	13.74	12.71

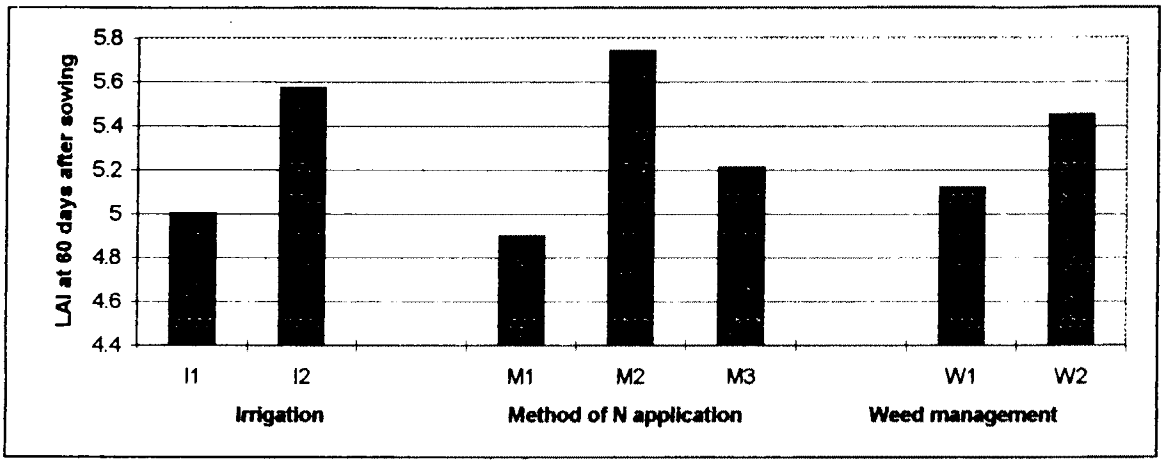

Fig. 4.1 Irrigation, method of N application and weed management on LAI at 60 DAS

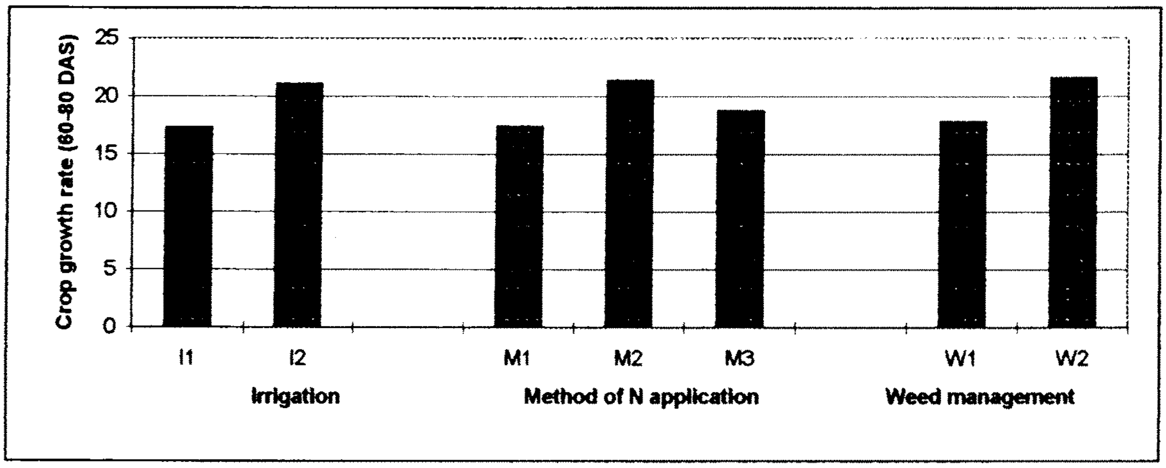

Fig. 4.2 Irrigation, method of N application and weed management on CGR at 60 - 80 DAS

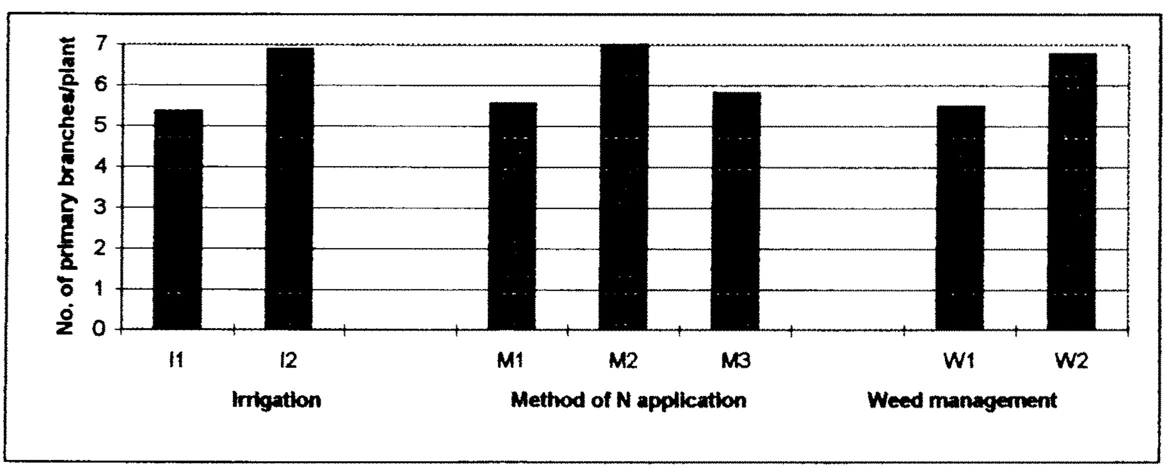

Fig. 4.3 Irrigation, method of N application and weed management on no. of primary branches/plant

effectivity over one irrigation in all the growth period on influencing the NAR values of the crops during both the years.

During all the growth stages the highest NAR values were obtained with the application of higher dose of N (80 Kg/ha) supplied half as basal and remaining half as top dressing before 1st irrigation and the differences in NAR values among the different methods of N application were also found significant in all the growth periods.

The data also indicates that pendimethalin proves its effectivity over linuron on influencing the NAR values of the crop and the differences among the two weed managing agents were also found significant.

The interaction effects between levels of irrigation and methods of N application; weed management and method of N application; irrigation, method of N application and weed management on influencing the NAR values of mustard were found not significant in all the growth stages of the crop.

4.1.2 Variation in yield components

Yield components of mustard such as plant height, no. of primary and secondary branches per plant, no. of siliqua per plant, number of seeds per siliquae and test height of grains recorded at maturity are presented below.

4.1.2.1 Height of the plants

Data recorded on height of the plants at maturity during 1995-96, 1996-97 and average of this two years (pooled) were statistically analysed and presented in table 4.5.

The results of the experiment indicated that the plant height at maturity did not significantly influenced due to levels of irrigation in both the years of experimentation and their pooled. Two irrigations ~~significantly~~ increases the plant height by 8.75% and 8.47% over one irrigation in 1995-96 and 1996-97 respectively. Increase in plant height with increasing levels of irrigations was also reported by Prihar *et al.* (1992) and Padmini *et al.* (1992).

Table 4.5 Effect of irrigation, method of N application and weed management on plant height, number of primary branches per plant and number of secondary branches per plant

Treatment	Plant height (cm)			No. of primary branches/plant			No. of secondary branches/plan		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Irrigation Level									
I_1	145.33	147.57	146.45	5.35	5.35	5.35	6.84	6.86	6.85
I_2	158.06	160.08	159.07	6.72	7.03	6.87	8.13	8.53	8.33
S.Em (±)	0.52	0.44	0.34	0.08	0.06	0.05	0.06	0.07	0.04
C.D. at 5%	NS	NS	NS	0.25	0.18	0.15	0.19	0.21	0.14
Method of N application									
M_1	147.26	147.81	147.54	5.55	5.55	5.55	6.80	7.10	6.95
M_2	158.72	161.77	160.25	6.86	7.09	6.98	8.14	8.57	8.36
M_3	149.10	151.90	150.50	5.69	5.93	5.81	7.51	7.40	7.45
S.Em (±)	0.63	0.54	0.41	0.10	0.07	0.06	0.08	0.08	0.06
C.D. at 5%	NS	NS	NS	0.31	0.22	0.18	0.23	0.25	0.17
Weed management									
W_1	145.75	148.00	146.87	5.39	5.55	5.47	6.96	7.03	7.00
W_2	157.63	159.66	158.65	6.68	6.84	6.76	8.01	8.35	8.18
S.Em (±)	0.52	0.44	0.34	0.08	0.06	0.05	0.06	0.07	0.04
C.D. at 5%	NS	NS	NS	0.25	0.18	0.15	0.19	0.21	0.14
C.V. %	11.46	11.22	11.34	10.09	13.29	12.25	12.75	13.97	12.86

Table 4.6 Interaction effects between irrigation, method of N application and weed management on plant height (cm)

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	131.66	142.76	141.93	**138.78**	132.46	149.73	144.20	**142.13**	132.06	146.25	143.06	**140.46**
	W_2	139.86	164.90	150.86	**158.87**	141.80	165.06	152.20	**153.02**	140.83	164.98	151.53	**152.45**
	Mean	**135.76**	**153.83**	**146.40**	**145.33**	**137.13**	**157.40**	**148.20**	**147.57**	**136.45**	**155.61**	**147.30**	**146.45**
I_2	W_1	153.16	154.13	150.86	**152.72**	151.86	156.93	152.80	**153.86**	152.51	155.53	151.83	**153.29**
	W_2	164.36	173.10	152.73	**163.40**	165.13	175.36	158.43	**166.31**	164.75	174.23	155.58	**164.85**
	Mean	**158.76**	**163.61**	**151.80**	**158.06**	**158.50**	**166.15**	**155.61**	**160.08**	**158.63**	**164.88**	**153.70**	**159.07**
$(I_1 + I_2)$	W_1	142.41	148.45	146.40	145.75	142.16	153.33	148.50	**148.00**	142.29	150.89	147.45	**146.87**
	W_2	152.11	169.00	151.80	**157.63**	153.46	170.21	155.31	**159.66**	152.79	169.60	153.55	**158.65**
	Mean	**147.26**	**158.72**	**149.10**	**151.69**	**147.81**	**161.77**	**151.90**	**153.83**	**147.54**	**160.25**	**150.50**	**152.76**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.522	NS	0.441	NS	0.341	NS
M	0.639	NS	0.540	NS	0.418	NS
I x M	0.904	NS	0.763	NS	0.591	NS
W	0.522	NS	0.441	NS	0.341	NS
I x W	0.738	NS	0.623	NS	0.483	NS
M x W	0.904	NS	0.763	NS	0.591	NS
I x M x W	1.27	NS	1.08	NS	0.837	NS
CV %	11.46		10.22		11.34	

The method of application of nitrogen though not found significant, the height of the plants influenced steadily with different methods of nitrogen application. Highest plant height was obtained with the application of 80 Kg N/ha, supplied half as basal and remaining half as top dressing before 1st irrigation. It was also revealed from the table (4.5) that lower dose of N (40 Kg/ha) applied fully through foliar sprays gave higher plant height than higher dose of N (80 Kg/ha) supplied only as basal dose. Similar findings were also reported by Lahiri and De (1971) and Mondal and Gaffer (1983).

Among the herbicides, the influence of pendimethalin on plant height was higher than linuron in both the years of experimentation as well as in pooled data. Pendimethalin (Stomp 30, EC @ 1.0 Kg. a.i./ha) increases the plant height by 8.15% and 7.87% over linuron (Afalon 50 WP @ 0.750 Kg a.i./ha) in 1995-96 and 1996-97 respectively. However, the treatment differences were not found significa

The interaction effect between levels of irrigation and method of nitrogen application; method of N application and weed management; irrigation and weed management; irrigation, method of nitrogen application and weed management on influencing height of the plants were found not significant during both the years of experimentation as well as pooled of this two years data (Table 4.6). The highest plant height (174.23 cm) was obtained when nitrogen (80 Kg/ha) were applied half (40Kg/ha) as basal and remaining half (40 Kg/ha) as top dressing before 1st irrigation with use of two irrigations and pendimethalin as weed managing treatment in case of pooled.

4.1.2.2 Number of primary branches per plant

The data on the production of primary branches per plant were recorded at maturity during both the years of experimentation and were statistically analysed and depicted in table 4.5.

The result showed that the no. of primary branches per plant influenced significantly due to different levels of irrigation during both the years as well as in pooled data. The higher no. of primary branches per plant was produced significantly due to application of two irrigations. Which was 25.6% and 31.4% higher than that of one irrigation applied at branching (30-35 DAS) stage in 1995-96 and 1996-97 respectively. Similar results were also obtained by Roy and Tripathy (1985) and Tomer *et al.* (1992).

The no. of primary branches per plant increased significantly with the methods of N application in both the years as well as in pooled data. The highest no. of primary branches per plant (6.86 and 7.09 in 1995-96 and 1996-97 respectively) was observed when N (80 Kg/ha) applied half (40 Kg/ha) as basal and remaining half half (40 Kg/ha) as top dressing before the 1st irrigation. Nitrogen (40 Kg/ha) applied only through foliar sprays gave significantly higher no. of primary branches per plant than when applied in higher dose (80 Kg/ha) only as basal.

Pendimethalin significantly increases the no. of branches per plant by 23.93% and 23.24% over linuron during 1995-96 and 1996-97 respectively through better management of weeds (Fig. 4.3).

The interaction effect between irrigation, method of N application and weed management was found not significant in 1995-96 but it was significant in 1996-97 and in pooled (Appendix table 1.1).

4.1.2.3 Number of secondary branches per plant

The data on the production of secondary branches per plant were recorded at maturity during both the years of experimentation and were statistically analysed and depicted in table 4.5.

The results showed that the no. of secondary branches per plant influenced significantly due to levels of irrigation, during both the years. The higher no. of secondary branches per plant were produced due to two irrigations over only one irrigation (Fig. 4.4). The percentage increase being 18.85, 24.34 and 21.60 during 1995-96, 1996-97 and pooled respectively.

The maximum no. of effective secondary branches per plant were recorded from the crop receiving nitrogen (80 Kg/ha) half as basal and remaining half through foliar sprays. The no. of effective secondary branches per plant was also increased significantly when the crop received low dose (40 Kg/ha) of N supplied only through

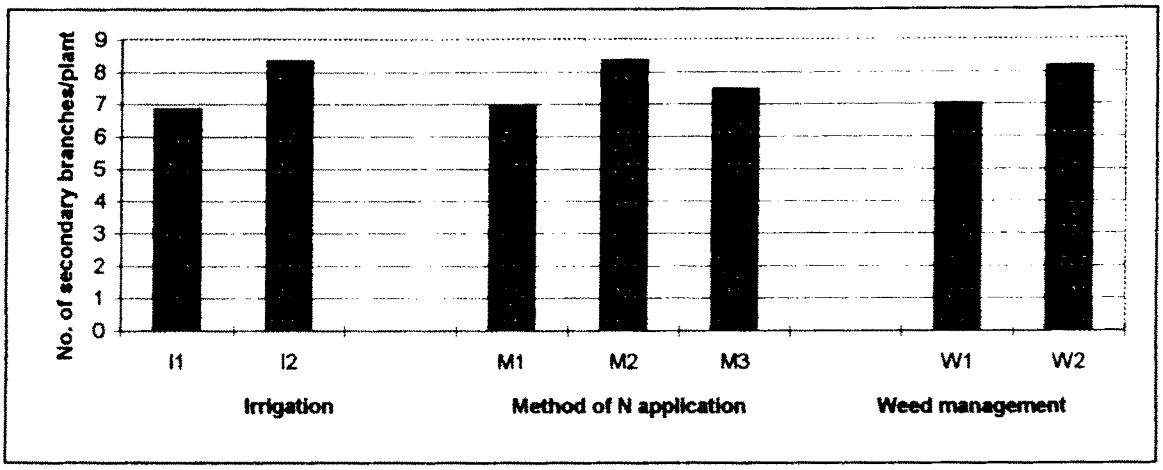

Fig. 4.4 Irrigation, method of N application and weed management on no. of secondary branches/plant

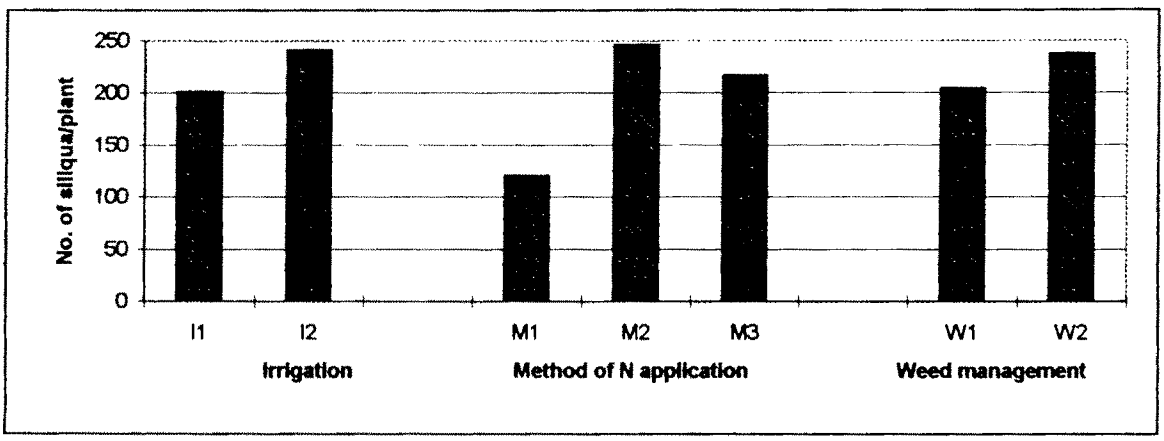

Fig. 4.5 Irrigation, method of N application and weed management on no. of siliqua/plant

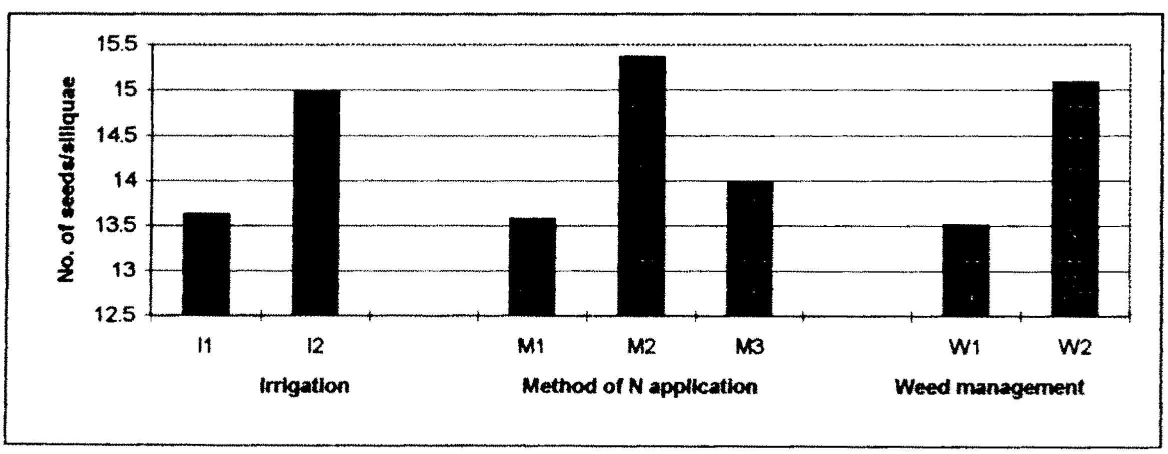

Fig. 4.6 Irrigation, method of N application and weed management on no. of seeds/siliquae

foliar sprays over higher dose (80 Kg/ha) applied only as basal. The same results was also observed by Tomer *et al.* (1991).

Pendimethalin gave significantly better results over linuron on influencing the no. of secondary branches per plant during both the years as well as in pooled and the percentage increase being 15.08, 18.77 and 16.85 in 1995-96, 1996-97 and pooled respectively.

The interaction effect between irrigation, method of N application and weed management on influencing the no. of secondary branches per plant was found significant in both the years as well as in pooled (Appendix table 1.2).

4.1.2.4 Number of siliqua per plant

The data recorded on number of siliqua per plant at maturity during 1995-96, 1996-97 and pooled were statistically analysed and presented in table 4.7.

The result showed that crops given two irrigations produced significantly greater no. of siliqua per plant than those of the crops receives only one irrigation. Two irrigations produced 25.51%, 14.62% and 19.79% higher no. of siliqua per plant than one irrigation in 1995-96, 1996-97 and pooled respectively. Significant increase in no. of siliqua per plant with one to two irrigations were also reported by Samui *et al.* (1986), Sharma (1991), Rama *et al.* (1991) and Prakash *et al.* (1992).

The no. of siliqua per plant increased significantly with the different methods of application of nitrogen. The highest no. of siliqua per plant was observed with the application of 80 Kg/ha of N, supplied half as basal and remaining half as top dressing before the 1st irrigation during both the years and in pooled. However, higher dose of N (80 Kg/ha) when applied only as basal produced lower no. of siliqua per plant than lower dose of N (40 Kg/ha) applied only through foliar spray (Fig. 4.5).

Pendimethalin gave 15.94, 16.42 and 16.18 percent increased no. of siliqua per plant over linuron through better management of weeds in 1995-96, 1996-97 and pooled and this increase were significant in both the years as well as in pooled.

Table 4.7 Effect of irrigation, method of N application and weed management on number of siliqua per plant , number of seeds per siliquae and test weight (g) of grain

Treatment	No. of siliqua per plant			No. of seeds per siliquae			Test weight (g)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Irrigation Level									
I_1	190.60	210.93	200.76	13.45	13.78	13.62	3.68	3.75	3.72
I_2	239.23	241.77	240.50	14.59	15.37	14.98	4.22	4.20	4.21
S.Em (±)	1.46	2.27	1.35	0.05	0.087	0.04	0.03	0.03	0.02
C.D. at 5%	4.30	6.68	3.88	0.17	0.21	0.13	NS	NS	NS
Method of N application									
M_1	188.62	211.10	119.86	13.39	13.75	13.57	3.77	3.79	3.78
M_2	244.22	247.35	245.78	15.09	15.63	15.36	4.21	4.26	4.24
M_3	211.90	22.60	216.25	13.59	14.35	13.97	3.88	3.87	3.87
S.Em (±)	1.79	2.79	1.65	0.06	0.08	0.05	0.04	0.04	0.03
C.D. at 5%	5.26	8.12	4.76	0.20	0.26	0.16	NS	NS	NS
Weed management									
W_1	199.05	209.17	204.11	13.33	13.70	13.51	3.70	3.72	3.71
W_2	230.78	243.53	237.15	14.71	15.46	15.08	4.20	4.23	4.21
S.Em (±)	1.46	2.27	1.35	0.05	0.07	0.04	0.03	0.03	0.02
C.D. at 5%	4.30	6.68	3.88	0.17	0.21	0.13	NS	NS	NS
C.V. %	12.90	10.27	11.68	11.70	12.07	11.90	13.63	13.85	13.74

The interaction effects between irrigation and methods or N application; irrigation and weed management ; methods or N application and weed management; irrigation, methods of N application and weed management were found significant on influencing the no. of siliqua per plant in both the years under study except the interactive effect of method on N application and weed management in 1996-97 (Appendix table 1.9). The highest no. of siliqua per plant was obtained with the crop received two irrigations one at branching, another at siliqua formation stage, higher dose of N (80 Kg/ha), supplied half as basal and remaining half as top dressing before the application of 1st irrigation and herbicide pendimethalin (Stomp 30 EC @ 1.0 Kg a.i./ha) used as weed managing treatment.

4.1.2.5 Number of seeds per siliquae

The data recorded on no. of seeds per siliquae at harvest during 1995-96, 1996-97 and pooled were statistically analysed and presented in table 4.7.

The result showed that crops given two irrigations produced significantly greater no. of seeds per siliquae than those of the crops gets only one irrigation. Two irrigations produced 8.47%, 11.53% and 9.98% higher no. of seeds per siliquae than one irrigation in 1995-96, 1996-97 and pooled respectively. Significant increase in no. of seeds per siliquae with one to two irrigations were also reported by Maity *et al.* (1982); Samui *et al.* (1986); Clarke and Simpson, 1987 and Tomer *et al.* (1992).

From the data it reveals that, no. of seeds per siliquae increased considerably due to the application of nitrogen either through basal, foliar and half basal-half top dressing methods during both the years of study (Table 4.7). Seed no. per siliquae increased steadily and significantly as methods of N application changed in both the years under study as well as in pooled. The highest no. of seeds per siliquae was noticed in crop at high N level (80 Kg/ha) supplied half through basal and remaining half as top dressing before the application of 1st irrigation and it was closely followed by the crop raised at lower N level (40 Kg/ha) supplied fully through foliar sprays. It was interesting to note that crop receiving lower level of N (40 Kg/ha) fully through foliar sprays produced more no. of seeds per siliquae than those obtained with higher dose of N (80 Kg/ha) supplied only through basal application during both the years as well as in pooled.

The data clearly indicates that pendimethalin significantly showed its effectivity over linuron on influencing the production of no. of seeds per siliquae of the crop through managing the weeds effectively at maturity during both the years as well as in pooled. The crop received pendimethalin as weed managing treatment produced 10.35, 12.84 and 11.62 percent more no. of seeds per siliquae than those received linuron during 1995-96, 1996-97 and in pooled respectively (Fig. 4.6).

The interaction effects between levels of irrigation and methods of N application; weed management and method of N application; irrigation, methods of N application and weed management were found significant in both the years of study as well as in pooled. However, the interaction effect of levels of irrigation and weed management though found significant in 1995-96 but it was not found significant in 1996-97 and in pooled (Appendix table 1.10). The highest no. of seeds per siliquae were (16.86 and 17.46) obtained when the crop was received two irrigations one at branching, another at siliquae formation stage; 80 Kg/ha of N supplied half as basal and remaining half as top dressing before the 1st irrigation; pendimethalin used as weed managing treatment during 1995-96, 1996-97 respectively and it was closely followed by (15.73 and 16.33) the crop received only one irrigation; nitrogen (80 Kg/ha) supplied half as basal and remaining half as top dressing before the irrigation; pendimethalin as well managing treatment.

4.1.2.6 Test weight of grain (1000-seed weight)

The test weight of mustard grain recorded at maturity during 1995-96 and 1996-97 were statistically analysed and shown in table 4.7.

The results revealed that the crop received two irrigations produced higher test weight than the crop got only one irrigation but the difference between these two were not significant in both the years of study.

Different methods of N application did not cause~~d~~ marked influence on increasing the test weight of mustard grains during both the years under study (Table 4.7). Crops receiving higher dose of N (80 Kg/ha) supplied half as basal and remaining half as top dressing increased the test weight over those received N at the dose of 80 Kg/ha supplied only as basal and also 40 Kg/ha of N supplied only through foliar sprays, though the increase was not appreciable.

did not

The data clearly indicates that pendimethalin showed its effectivity over linuron in influencing the 1000-grain weight of mustard through managing the weeds effectively during both the years as well as in pooled. The percentage increase were 13.51 and 13.70 in 1995-96 and 1996-97 respectively, and not appreciable.

The interaction effects between levels of irrigation and methods of N application; weed management and levels of irrigations; method of N application and weed management; levels of irrigations, method of N application and weed management on influencing the test weight of mustard grain were found not significant during both the years under study as well as in pooled.

4.1.3 Variation in crop productivity

Seed yield, stover yield, harvest index and oil content recorded at maturity of the crop have been summerised below.

4.1.3.1 Seed yield

Seed yield of mustard recorded at maturity from the individual plots receiving different treatments during 1995-96, 1996-97 and their pooled were statistically analysed and presented in table 4.8.

The result showed that crops given two irrigations produced significantly greater seed yield (1215.36 Kg/ha) than those of the crops got only one irrigation (882.80 Kg/ha). Two irrigation produced 38.29% and 37.09% higher seed yield than crops given only one irrigation in 1995-96 and 1996-97 respectively. The good effect of application of irrigation to mustard yield had also been highlighted by many workers (Krogman and Hobbes 1975; Prihar *et al.,* 1981; Khan and Agarwal, 1985; Singh and Srivastava, 1986; Samui *et al.,* 1986; Prasad and Eshanhullah, 1988; Singh *et al.,* 1989 and Prakash *et al.,* 1992).

The result showed very high response of mustard to the applied nitrogen (Table 4.8). Seed yield increased steadily and significantly due to the application of nitrogen either as basal, foliar and half basal-half top dressing methods during both the years of study and their pooled data. Maximum seed yield (1287.66, 1396.75 and 1342.20 Kg/ha in 1995-96, 1996-96 and pooled respectively) was recorded in crop raised with

Table 4.8 Effect of irrigation, method of N application and weed management on seed yield, stover yield, harvest index, oil content and oil yield.

Treatment	Seed yield (kg/ha)			Stover yield (kg/ha)			Harvest index			Oil content (%)			Oil yield (kg/ha)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Irrigation level															
I_1	847.61	918.00	882.80	2810.21	2983.12	2896.66	22.49	22.85	22.67	38.38	38.74	38.56	327.73	358.13	342.93
I_2	1172.22	1258.50	1215.36	3361.12	3614.09	3487.57	25.58	25.49	25.53	39.13	39.23	39.18	460.68	495.52	478.10
S.Em (±)	11.75	14.15	9.19	44.33	29.01	26.49	0.29	0.14	0.16	0.05	0.08	0.04	4.61	5.64	3.64
C.D. at 5%	34.46	41.45	26.40	130.01	85.09	76.04	0.87	0.44	0.48	NS	NS	NS	13.52	16.56	10.46
Method of N application															
M_1	822.91	877.58	850.25	2718.49	2913.61	2816.05	22.48	22.46	22.47	38.42	38.71	38.57	318.62	342.29	330.45
M_2	1287.66	1296.75	1342.20	3603.56	3850.92	3727.24	25.95	26.19	26.07	39.40	39.45	39.42	509.66	553.40	531.53
M_3	919.16	990.41	954.79	2934.94	3131.17	3033.06	23.67	23.87	23.77	38.45	38.80	38.62	354.32	384.78	369.55
S.Em (±)	14.39	17.33	11.26	54.29	33.53	32.44	0.36	0.18	0.20	0.06	0.10	0.05	5.64	6.91	4.46
C.D. at 5%	42.20	50.78	32.33	159.23	104.22	93.13	1.06	0.537	0.582	NS	NS	NS	16.56	20.28	12.81
Weed management															
W_1	811.94	871.66	841.80	2738.03	2917.59	2827.81	22.55	22.71	22.63	38.30	38.60	38.45	311.80	336.91	324.45
W_2	1207.88	1304.83	1256.36	3433.30	3679.55	3556.42	25.51	25.64	25.58	39.21	39.38	39.29	476.60	516.74	496.67
S.Em (±)	11.75	14.15	9.19	44.34	29.01	26.49	0.29	0.14	0.16	0.05	0.08	0.04	4.61	5.64	3.64
C.D. at 5%	34.46	41.46	26.40	130.01	85.09	76.04	0.87	0.44	0.48	NS	NS	NS	13.52	16.56	10.46
C.V. %	12.94	12.52	12.26	12.10	13.73	12.98	13.21	12.63	14.12	10.55	10.91	10.75	14.96	13.61	14.33

Table 4.9 Interaction effects between irrigation, method of N application and weed management on seed yield (kg/ha)

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	415.33	906.66	710.66	**677.55**	480.33	935.66	771.33	**729.11**	447.83	921.16	741.00	**703.33**
	W_2	662.66	1479.00	911.33	**1017.66**	714.00	1617.33	989.33	1106.88	**688.33**	1548.86	950.33	1062.27
	Mean	**539.00**	**1192.83**	**811.00**	**847.61**	**597.16**	**1276.50**	**880.33**	**918.00**	**568.08**	**1234.66**	**845.66**	**882.80**
I_2	W_1	910.00	1020.0	909.00	**946.33**	934.66	1126.00	982.00	**1014.22**	922.33	1073.00	945.50	**980.27**
	W_2	1303.66	1745.00	1145.00	**1398.11**	1381.33	1908.00	1219.00	**1502.77**	1342.50	1826.50	1182.33	**1457.44**
	Mean	**1106.83**	**1382.50**	**1027.33**	**1172.22**	**1158.00**	**1517.00**	**1100.50**	**1258.50**	**1132.41**	**1449.75**	**1063.91**	**1215.36**
($I_1 + I_2$)	W_1	662.66	963.33	809.83	811.94	707.50	1030.83	876.66	**871.66**	685.08	997.08	843.25	**841.80**
	W_2	983.16	1612.00	1028.50	**1207.88**	1047.66	1762.66	1104.16	**1304.83**	1015.41	1687.33	1066.33	**1256.33**
	Mean	**822.91**	**1287.7**	**919.16**	**1009.91**	**877.58**	**1396.76**	**990.41**	**1088.25**	**850.25**	**1342.2**	**954.79**	**1049.08**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	11.75	34.46	14.15	41.45	9.19	16.40
M	14.39	42.20	17.33	50.78	11.26	32.33
I x M	20.35	59.69	24.51	71.82	15.93	45.72
W	11.75	34.46	14.15	41.46	9.19	26.40
I x W	16.61	48.73	20.01	58.64	13.00	37.33
M x W	20.35	59.69	24.51	71.82	15.93	45.72
I x M x W	28.78	NS	34.66	NS	22.53	NS
CV %	12.94		12.52		12.26	

high N level (80 Kg/ha), supplied half as basal and remaining half as top dressing before the application of the 1st irrigation. It was significantly higher than those obtained from al other nitrogen treatments under study.

However, it is interesting to note that the crop receiving low level of nitrogen (40Kg/ha) supplied only through foliar sprays recorded significantly higher seed yield than the crop received higher level of N (80 Kg/ha) supplied only through basal application. This showed the superiority of foliar spraying of N over only basal application in increasing the crop productivity. The result clearly indicated the need for the application of high level of N (80 Kg/ha) supplied through split doses for obtaining high yield from mustard under this region of West Bengal. Supply of N, half as basal and rest as top dressing proved to be better than application of only basal or only foliar spraying for maximising the productivity of mustard under this ecological condition. The increase in yield due to application of N through split doses were also evidenced by Lahiri and De (1971), Mondal and Goffer (1983), Goffer and Rajjaque (1984) and Berti and Mosca (1987).

The data clearly indicates that pendimethalin has significantly higher influence on the production of seed yield than linuron through better suppression of weeds, infested in mustard field. The crop received pendimethalin (Stomp 30 EC @ 1.0 Kg.a.i./ha) as weed managing treatment produced significantly higher yield than those received linuron (Afalon 50 WP @ 0.750 Kg.a.i./ha) in both the years of study as well as in pooled. Pendimethalin treated crop produced 48.76%, 49.66% and 49.24% more yield of mustard than linuron in 1995-96, 1996-97 and pooled respectively. It proved the effectivity of pendimethalin in better management of weeds grown in the mustard field. The effectivity of pendimethalin was also proved by Adamczewski *et al.*, 1987; Mohamed, 1988; Dixon *et al.*, 1989; Dubey *et al.*, 1988.

The interactive effects between levels of irrigation and method of nitrogen application; weed management and levels of irrigation; weed management and method of nitrogen application though found significant on influencing the seed yield of mustard but the interaction effect between levels of irrigation, method of N application and weed management was found not significant in both the years of experimentation and in pooled data (Table 4.9). For the interaction of levels of irrigation and methods of N

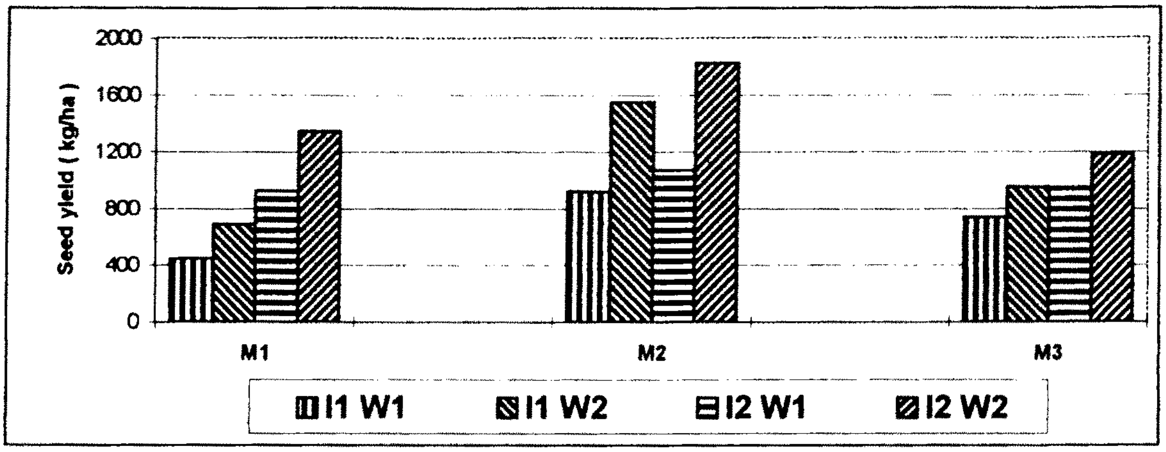

Fig. 4.7 Interaction effect of irrigation, method of N application and Weed management on seed yield

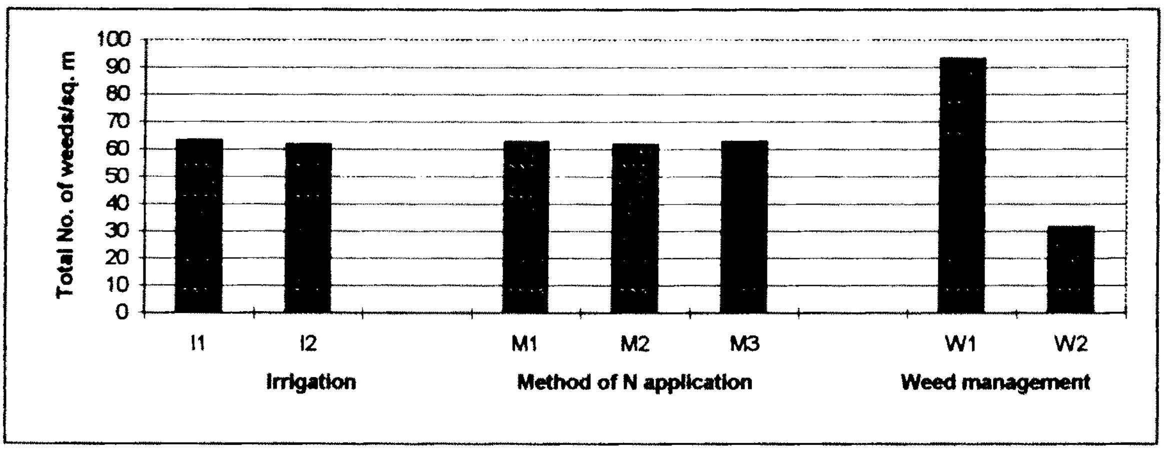

Fig. 4.8 Irrigation, method of N application and weed management on total no. of weeds/sq. m

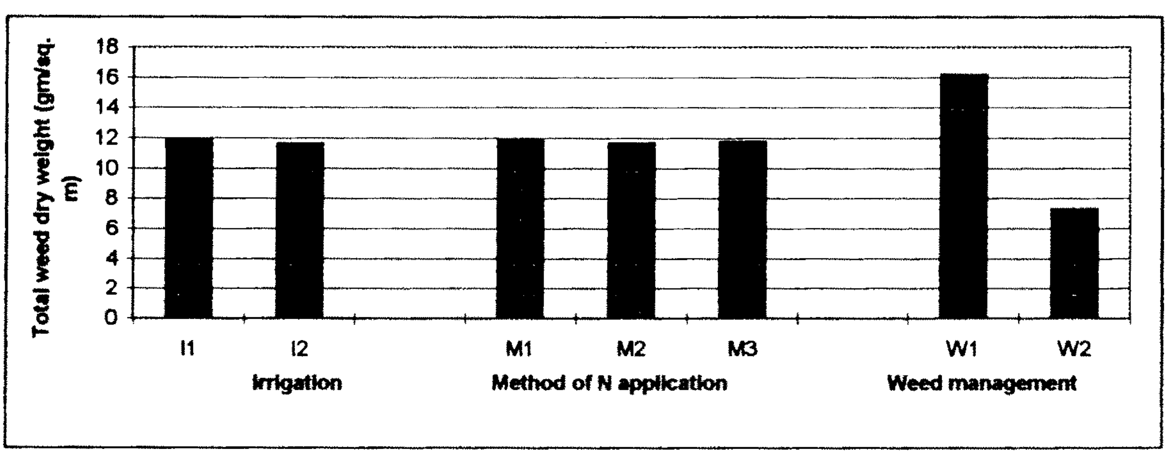

Fig. 4.9 Irrigation, method of N application and weed management on total weed dry weight (gm/sq. m)

application the highest seed yield (1382.50 Kg/ha) was obtained with the application of two irrigation and 80 Kg of N/ha supplied half as basal and remaining half through top dressing before the application of 1st irrigation. Among the interaction effect of levels of irrigation and weed management the highest seed yield (1398.11 Kg/ha) was obtained when two irrigation were applied to the crop and the weed management when done through the application of pendimethalin in the form of Stomp 30 EC @ 1.0 Kg.a.i./ha. Among the interaction effects of method of N application and weed management the highest seed yield (1612 Kg/ha) was obtained when the crop has given 80 Kg N/ha supplied half as basal and remaining half as top dressing before the application of 1st irrigation and the weed management were done through the application of pendimethalin in the form of Stomp 30 EC @ 1.0 Kg.a.i./ha (Fig. 4.7).

4.1.3.2 Stover yield

The stover yield of mustard recorded at maturity during 1995-96, 1996-97 and their pooled was statistically analysed and presented in table 4.8.

The results showed that the crops got two irrigations one at branching and another at siliqua formation stage produced higher quantity of stover which was significantly greater than in those of the crops got only one irrigation at branching stage. Like seed yield, stover yield also decreased steadily and significantly as the no. of irrigation decreased during both the years under study as well as in pooled data. The results clearly indicated that mustard should be given two irrigations to obtained good growth of the crop under this region of West Bengal.

The results further revealed that the stover yield was significantly influenced by the method of application of N during both the years under study (Table 4.8). Minimum quantity of stover was produced from the plot received 80 Kg N/ha, supplied half as basal and remaining half as top dressing during both 1995-96, 1996-97 and pooled. This was significantly superior to the stover yields obtained from all other N treatment under study.

From the data it reveals that pendimethalin in the form of Stomp 30 EC @ 1.0 Kg a.i./ha helps in producing significantly higher stover yield than that of linuron in the form of Afalon 50 WP @ 0.750 Kg a.i./ha during both the years. The difference between the produced quantity of stover by pendimethalin and linuron treated crop were 25.39, 26.11 and 25.76 per cent in 1995-96, 1996-97 and their pooled. This clearly showed the benefit of pendimethalin over linuron in suppressing the weed of the mustard yield effectively.

The interaction effects between levels of irrigation and method of N application; weed management and method of N application; levels of irrigation, method of N application and weed management on influencing the stover yield of mustard though found significant but the interaction between levels of irrigation and weed managing treatments was found not significant in 1995-96, 1996-97 as well as in pooled (Appendix table 1.11).

4.1.3.3 Harvest index

Harvest index estimated from grain and stover yield at maturity during 1995-96, 1996-97 and pooled were statistically analysed and placed in table 4.8.

The results showed that the crops received two irrigations gave the higher values of harvest index than one irrigation in both the years and the differences were also significant. The result indicated that not only the crop productivity but also the efficiency in partitioning photosynthates for grain production decreased markedly due to reduction in no. of irrigation.

Harvest index of the crop was influenced favourably by the application of nitrogen through different methods during 1995-96, 1996-97 and pooled. Significant increase in harvest index was noticed in crop receiving 80 Kg of N/ha supplied half as basal and remaining half as top dressing before the application of 1st irrigation over other methods of N application. The difference in harvest indices were also significant among the different nitrogen management treatments during both the years under study.

The harvest index of mustard was also influenced at varying weed management treatments. Pendimethalin in the form of Stomp 30 EC @ 1.o Kg a.i./ha produced significantly higher harvest indices value over linuron (Afalon 50 WP @ 0.750 Kg a.i./ha) treated crops.

The interaction effects between levels of irrigation and method of N application; method of N application and weed management though found significant on influencing the harvest indices values of mustard but the interaction effects between levels of irrigation and weed management; levels of irrigation, method of N application and weed management on influencing the above were not found significant in 1995-96, 1996-97 and pooled (Appendix table 1.12).

4.1.3.4 Oil content

Oil content in mustard grain estimated at maturity was statistically analysed and presented in table 4.8.

The results showed that oil content did not vary much among the two irrigation levels. Slight increase in oil content was there due to two irrigation over only one irrigation.

Nitrogen treatments also showed slight effect on influencing the oil content in mustard grain during both the years under study (Table 4.8). Crop receiving high level of N (80 Kg/ha), supplied half as basal and remaining half as top dressing recorded higher content of oil in its grain than those of the crop receiving higher dose of N (80Kg/ha) supplied fully as basal dose or crop receiving lower dose of N (40 Kg/ha) supplied fully through foliar sprays but the differences were not significant.

Similarly, the oil content of mustard did not vary much among the two herbicide treatments. The oil content was increased from 38.45 to 39.38 due to the influence of pendimethalin to linuron in the pooled data (Table 4.8) and also this increase was not significant.

The interaction effects of levels of irrigation and method of N application; levels of irrigation and weed management ; method of N application and weed management and levels of irrigation, method of N application and weed management on influencing the oil content were found not significant in both the years of study as well as in pooled (Appendix table 1.13).

4.1.4 Variation in weed infestation

The data on weed population and dry weight of weeds as influenced by irrigation, method of nitrogen application and weed managing treatments recorded at 60 days after sowing of mustard during 1995-96, 1996-97 and their pooled were analysed and presented in table 4.10.

4.1.4.1 Weed flora

The weeds collected from the experimental plots were categorised and the species were identified during both the years. The broadleaf weed species found in the experimental plots were *Anagallis arvensis, Amaranthus retroflexous, Amaranthus spinosus, Amaranthus viridis, Asphodelus tenuifolius, Chenopodium album, Cirsium arvense, Convolvulus arvensis, Euphorbia hitra, Fumaria parviflora, Melilotus alba, Melilotus indica, Oxalis repens, Polygonium convolvulus, Portulaca oleracea, Solanum nigram, Vicia hirsuta, Cyperus* Spp., *Ageratum Conyzoides, Boerhavia diffusa* and *Eclipta alba;* the grasses were *Eleusine indica, Echinochloa crus-galli, Panicum repens, Digitaria sanguinalis, Cynodon dactylon, Imperata cylindrica, Poa anua* and *Setaria* sp.; *Cyperus rotundus* and *Cyperus* spp. were the sedges. The predominant weeds were *Anagallis arvensis, Chenopodium album, Elusine indica, Panicum repens* and *Cyperus rotundus.*

4.1.4.2 Categorised weed density

The population of grasses, sedges and broadleaf weeds were categorised treatment wise, analysed and presented in table 4.10.

The results showed that the experimental field were severely infested with sedges as compared to broad leaved and grasses during both the years under study.

The results showed that the no. of grasses/sq. m, sedges/sq. m, broad leaved/sq. m and total no. of weeds/sq. m were not influenced significantly with increase in the no. of irrigation from one to two.

Among the different methods of N application the no. of different weeds/sq. m separately and the total no. of weeds/sq. m were also not influenced significantly. The

Table 4.10 Effect of irrigation, method of N application and weed management on weed density and weed dry weight

Treatment	No. of grasses/sq. m			No. of sedges/sq. m			No. of broad leaved/sq. m			Total no. of weeds/sq. m			Total weed dry wt. (g/sq. m)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Irrigation level															
I_1	11.95	13.15	12.55	34.23	34.11	34.17	16.66	15.90	16.28	62.85	63.17	63.01	11.81	11.86	11.83
I_2	12.85	13.31	13.05	32.16	33.41	32.79	15.38	16.20	15.79	60.40	62.71	61.55	11.36	11.84	11.60
S.Em (±)	0.36	0.45	0.29	0.93	0.68	0.57	0.35	0.42	0.27	1.48	1.36	1.00	0.43	0.38	0.28
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Method of N application															
M_1	12.47	13.82	13.15	33.25	34.70	33.97	16.05	15.40	15.72	61.77	63.59	62.68	11.30	12.24	11.77
M_2	12.52	12.80	12.66	31.87	33.62	32.75	15.87	16.52	16.20	60.27	62.95	61.61	11.43	11.88	11.65
M_3	12.20	13.08	12.64	34.47	32.97	33.72	16.15	16.22	16.18	62.82	62.28	62.55	12.03	11.43	11.73
S.Em (±)	0.44	0.55	0.35	1.14	0.84	0.70	0.43	0.52	0.33	1.81	1.67	1.23	0.52	0.46	0.35
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed management															
W_1	20.35	21.12	20.73	50.06	50.45	50.25	21.93	22.41	22.17	92.35	93.76	93.05	15.57	16.76	16.17
W_2	4.45	5.35	4.90	16.33	17.08	16.70	10.11	9.68	9.90	30.90	32.11	31.50	7.59	6.94	7.27
S.Em (±)	0.36	0.45	0.29	0.93	0.68	0.57	0.35	0.42	0.27	1.48	1.36	1.00	0.43	0.38	0.28
C.D. at 5%	1.07	1.32	0.83	2.73	2.01	1.66	1.03	1.24	0.79	4.34	1.52	2.89	1.26	0.38	0.28
C.V. %	12.55	14.46	13.61	11.91	8.63	10.37	9.32	11.24	10.32	10.20	9.23	9.72	15.77	13.65	14.73

Table 4.11 Interaction effects between irrigation, method of N application and weed management on total number of weeds per sq.m.

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	90.50	96.10	91.30	**92.63**	87.56	84.03	80.90	**84.16**	82.25	95.40	90.71	**92.78**
	W_2	36.80	24.70	37.70	**33.06**	32.90	26.70	40.70	**33.43**	37.25	26.45	36.00	**33.23**
	Mean	**63.65**	**60.40**	**64.50**	**62.85**	**60.23**	**55.36**	**60.80**	**58.80**	**64.75**	**60.92**	**63.35**	**63.01**
I_2	W_1	89.90	91.50	94.80	**92.07**	81.20	82.13	86.50	**83.27**	89.98	95.55	94.45	**93.32**
	W_2	29.90	28.80	27.50	**28.73**	33.80	25.70	33.70	**35.06**	31.25	29.05	29.05	**29.78**
	Mean	**59.90**	**60.15**	**61.15**	**60.40**	**57.50**	**53.91**	**60.10**	**57.17**	**60.61**	**62.30**	**61.75**	**61.55**
$(I_1 + I_2)$	W_1	90.20	93.80	93.05	92.35	84.38	83.08	83.70	**83.72**	91.11	95.47	92.58	**93.05**
	W_2	33.35	26.75	32.60	**30.90**	33.35	26.20	37.20	**32.25**	34.25	27.75	32.52	**31.50**
	Mean	**61.77**	**60.27**	**62.82**	**61.62**	**58.86**	**54.64**	**60.45**	**57.98**	**62.68**	**61.61**	**62.55**	**62.28**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	1.48	NS	0.520	NS	1.00	NS
M	1.81	NS	0.637	NS	1.23	NS
I x M	2.56	NS	0.901	NS	1.74	NS
W	1.48	4.34	0.520	1.52	1.00	2.89
I x W	2.098	NS	0.736	NS	1.42	NS
M x W	2.56	NS	0.901	NS	1.74	NS
I x M x W	3.63	NS	1.27	NS	2.47	NS
CV %	13.20		13.81		14.72	

Table 4.12 Interaction effects between irrigation, method of N application and weed management on total weed dry weight (gm/sq. m)

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	14.79	17.41	15.08	**15.76**	16.85	17.02	15.18	**16.35**	15.82	17.21	15.13	**16.05**
	W_2	8.62	9.78	9.18	**7.86**	9.18	5.72	7.25	**7.38**	**8.90**	5.75	8.21	7.62
	Mean	**11.70**	**11.59**	**12.13**	**11.81**	**13.01**	**11.37**	**11.21**	**11.86**	**12.36**	**11.48**	**11.67**	**11.83**
I_2	W_1	14.12	15.25	16.82	**15.31**	15.92	18.62	17.00	**17.18**	15.02	16.93	16.91	**16.28**
	W_2	7.68	7.28	7.04	**7.33**	7.02	6.18	6.32	**6.50**	7.35	6.73	6.68	**6.92**
	Mean	**10.90**	**11.26**	**11.93**	**11.36**	**11.47**	**12.40**	**11.66**	**11.84**	**11.18**	**11.83**	**11.79**	**11.60**
$(I_1 + I_2)$	W_1	14.43	16.33	15.95	**15.57**	16.38	17.82	16.09	**16.75**	15.42	17.07	16.02	**16.17**
	W_2	11.30	11.43	12.03	**11.58**	12.24	11.88	11.43	**11.85**	11.77	11.65	11.73	**11.72**
	Mean	**11.30**	**11.43**	**12.03**	**11.58**	**12.24**	**11.88**	**11.43**	**11.85**	**11.77**	**11.65**	**11.73**	**11.72**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.430	NS	0.381	NS	0.287	NS
M	0.527	NS	0.467	NS	0.352	NS
I x M	0.746	NS	0.660	NS	0.498	NS
W	0.430	1.26	0.381	1.11	0.287	0.825
I x W	0.609	NS	0.539	NS	0.406	NS
M x W	0.746	NS	0.660	NS	0.498	NS
I x M x W	1.05	NS	0.934	NS	0.704	NS
CV %	12.77		13.65		12.73	

no. of different weeds obtained per sq. m of field area were statistically at par with the application of N in different methods.

The data clearly indicated that the no. of grasses per sq.m, sedges/sq. m, broad leaved/sq. m and also the total no. of weeds/sq. m were significantly and steadily influenced due to the application of two herbicides. Pendimethalin in the form of Stomp 30 EC @ 1.0 Kg a.i./ha produced significantly lower no. of grasses, sedeges, broad leved and total no. of weeds per sq. m (Fig. 4.8) than that of the crop receives linuron as Afalon 50 WP @ 0.750 Kg a.i./ha both as pre-emergence herbicides during 1995-96, 1996-97 and pooled. It proved that pendimethalin was more effective in suppressing the infestation of weeds of mustard than linuron in this region of West Bengal. The effectivity of pendimethalin was also observed by Mohamed, 1988; Dubey *et al.*, 1988; Ibrahim *et al.*, 1988 and Dixon *et al.*, 1989.

The interaction effects between levels of irrigation and methods of N application; levels of irrigation and weed management; method of N application and weed management; levels of irrigation, methods of N application and weed managing treatments were found not significant in influencing the infestation of weeds in mustard field during both the years of experimentation and in pooled (Table 4.11).

4.1.4.3 The dry weight of weeds

The dry weight of weeds recorded at 60 DAS were statistically analysed and presented in table 4.10.

The dry weight of weeds did not vary much through the influence of levels of irrigation during both the years as well as in pooled. the differences of dry weight of weeds infested in plots receiving one and two irrigations were also found not significant in 1995-96, 1996-97 and pooled.

The data showed that the weed dry weights did not differ much due to variation in method of N application in either or the two years of experimentation as well as in pooled. This indicated that the method of N application had no effect on weed dry weight of mustard field.

Table 4.12A Effect of different management practices on uptake of nutrients in irrigated soil (Pooled data of two years)

Method of N application → Irrigation & weed management ↓		M_1			M_2			M_3			Mean		
		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	W_1	14.91	7.43	18.40	30.67	15.29	37.85	24.67	12.30	30.45	**23.42**	**11.67**	**28.90**
I_1	W_2	22.92	11.42	28.29	51.57	25.71	63.65	31.64	15.77	39.05	**35.37**	**17.63**	**43.65**
	Mean	**18.91**	**9.42**	**23.34**	**41.11**	**20.49**	**50.74**	**28.16**	**14.03**	**34.75**	**29.39**	**14.65**	**36.28**
	W_1	30.71	15.31	37.90	35.73	17.81	44.10	31.48	15.69	38.86	**32.64**	**16.27**	**14.28**
I_2	W_2	44.70	22.28	55.17	60.82	30.31	75.06	39.37	19.62	48.59	**48.53**	**24.19**	**59.90**
	Mean	**37.70**	**18.79**	**46.54**	**48.28**	**24.06**	**15.58**	**35.42**	**17.66**	**43.72**	**40.47**	**20.17**	**49.95**
	W_1	22.81	11.37	28.15	33.20	16.55	40.97	28.08	19.99	34.65	**28.03**	**13.97**	**34.59**
($I_1 + I_2$)	W_2	33.81	16.85	41.73	56.18	28.00	69.34	35.50	17.70	43.82	**41.83**	**20.85**	**51.63**
	Mean	**28.31**	**14.11**	**34.94**	**44.69**	**22.28**	**55.16**	**31.79**	**15.84**	**39.24**	**34.93**	**17.41**	**43.11**

The results showed that the dry weight of weeds increased steadily and significantly with the application of linuron over pendimethalin in both the years of experimentation as well as in pooled. The lower dry weight of weeds recorded from the plots receiving pendimethalin in the form of Stomp 30 EC @ 1.0 Kg a.i./ha than that of the plots receiving linuron in the form of Afalon 50 WP @ 0.750 Kg a.i./ha. and the differences were also significant (Fig. 4.9). So, it proves that crops receiving pendimethalin, faced relatively less weed infestation than crops receiving linuron and accordingly recorded lower level of weed dry weights during both the years under study as well as in pooled.

The interaction effects between levels of irrigation and method of N application; levels of irrigation and weed management; method of N application and weed management; levels of irrigation, method of N application and weed management were found not significant in influencing the dry weight of weeds infested in mustard field (Table 4.12).

4.1.5 Uptake of nutrients

The uptake of N, P and K were calculated on dry weight basis by multiplying the dry matter yield with their corresponding content of nutrient element and presented in table 4.12A.

It was observed that uptake of N, P and K were associated with seed yield differences due to different treatment effects under different management practices. The potassium showed highest uptake followed by nitrogen. The phosphorus showed lesser uptake.

4.1.6 Economics of mustard production

Cost of cultivation, net return and return per rupee invested had been worked out analysed and presented in table 4.13.

The results showed that crops receiving two irrigations reported significantly higher net return (Rs. 8484 ha^{-1}) than those of the crops receiving only one irrigation inspite of its high cost of cultivation due to high productivity through more irrigation. Similar trend of results were also observed in case of return per rupee invested. Maximum return (1.56) per rupee invested was obtained from the crop received two

Table 4.13 Effect of irrigation, methods of nitrogen application and weed management on economics of mustard cultivation (average over 2 years data)

Treatment	Cost of cultivation (Rs./ha)	Net return (Rs/ha)	Return per rupee invested
Irrigation level			
I_1	5038	5238	1.03
I_2	5413	8484	1.56
S.Em (±)		268	0.32
C.D. at 5%		769	0.91
Method of N application :			
M_1	4960	4950	0.99
M_2	5260	10025	1.90
M_3	4820	6244	1.29
S.Em (±)		275	0.42
C.D. at 5%		789	1.20
Weed management :			
W_1	4601	5231	1.13
W_2	4626	9715	2.10
S.Em (±)		269	0.79
C.D. at 5%		772	2.26
C.V. %		18.2	17.8

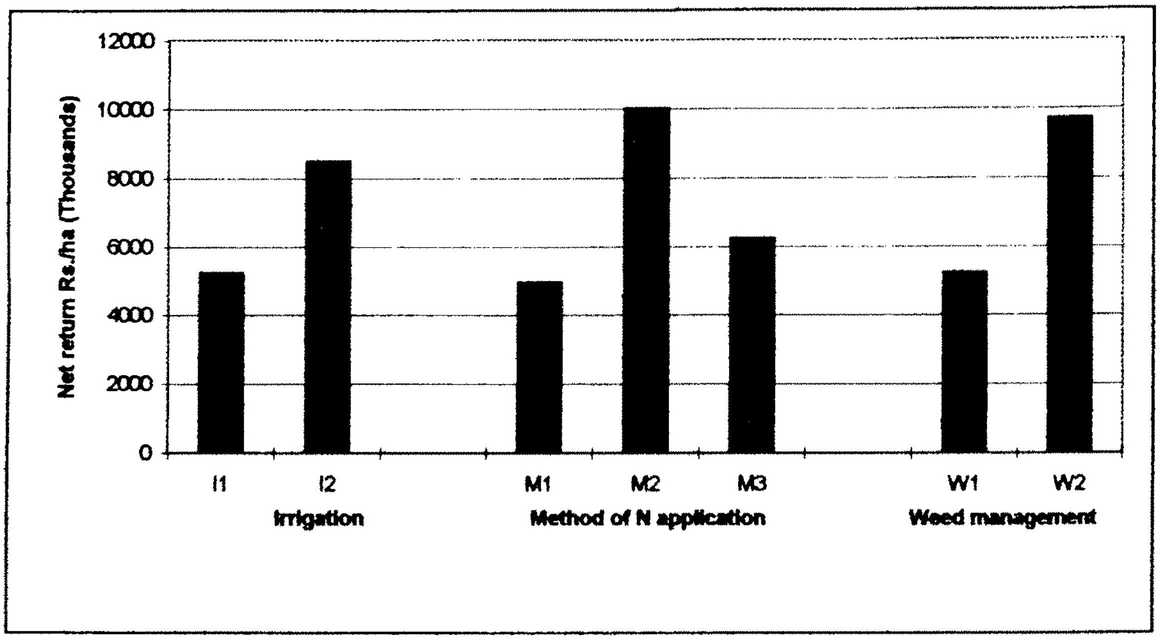

Fig. 4.10 Irrigation, method of N application and weed management on net return (Rs/ha)

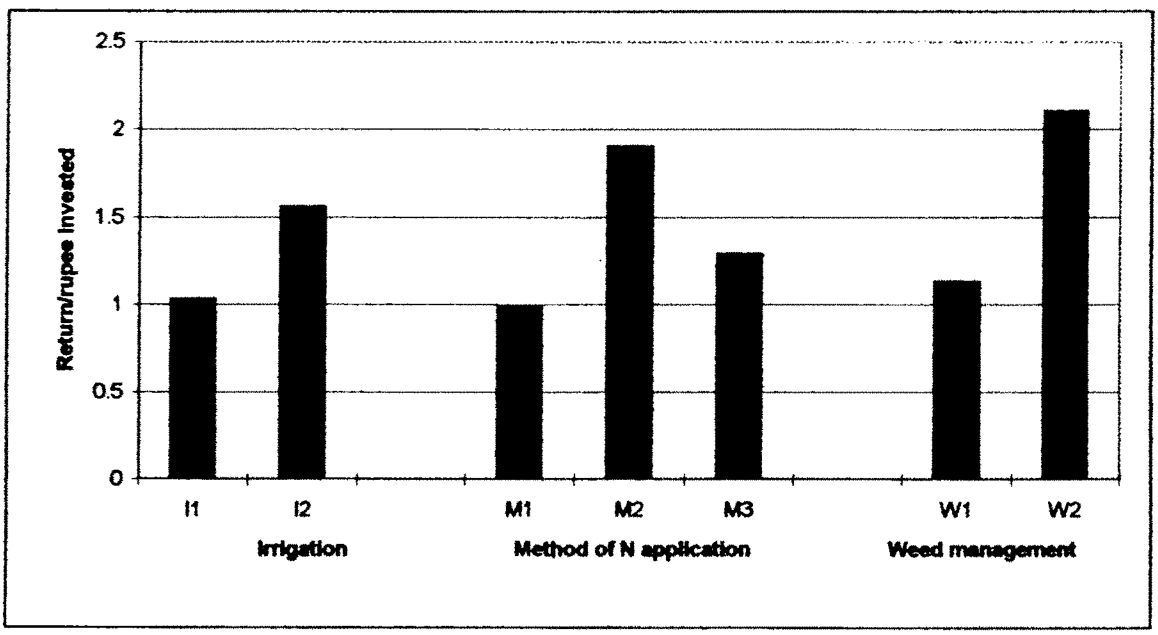

Fig. 4.11 Irrigation, method of N application and weed management on return/rupee invested

irrigation. It was highly remunerative and was significantly higher than obtained with the crop receiving only one irrigation.

Method of nitrogen application also showed significant effect on influencing the economics of mustard production (Table 4.13). Net return from mustard increased significantly and steadily due to application of nitrogen in different methods. The highest net return (Rs. 10025 ha^{-1}) was obtained from the crop receiving 80 Kg ha^{-1} of nitrogen supplied half as basal and remaining half as top dressing before the application of 1st irrigation and it was significantly superior to all other methods of N application under study (Fig. 4.10). Crops at lower nitrogen level (40 Kg/ha) supplied entirely through foliar sprays also paid very high net return (Rs. 6244 ha^{-1}) and which was significantly higher than those obtained with the application of higher dose (80 Kg/ha) of nitrogen supplied fully as basal. The lowest net return (Rs. 4950 ha^{-1}) was recorded in crop receiving higher level of nitrogen (80 Kg/ha) supplied only as basal application. The return per rupee invested also vary much due to the method of nitrogen management. Highest return per rupee invested (1.90) was obtained from the crop receiving higher level of N (80 Kg/ha) supplied half as basal and remaining half as top dressing before the application of 1st irrigation. It was highly remunerative and was significantly higher than with the crop receiving higher level of N (80 Kg/ha) supplied fully as basal and lower level of N (40 Kg/ha) supplied fully through foliar sprays in four split doses (Fig. 4.11). The results clearly showed the benefit of split application of nitrogenous fertilizer half as basal and remaining half as top dressing for mustard cultivation under this new alluvial region of West Bengal.

The results also clearly indicated that crop receiving pendimethalin (Stomp 30 EC @ 1.0 Kg a.i./ha) for weed management reported significantly higher net return (Rs. 9715 ha^{-1}) than those of the crop receiving linuron (Afalon 50 WP @ 0.750 Kg a.i./ha) as weed managing treatment due to high productivity through better weed management. Similar trend of results were also observed in case of return per rupee invested. Maximum return per rupee invested was obtained from the crop received pendimethalin for weed management as Stomp 30 EC @ 1.0 Kg a.i./ha. It was very highly remunerative and was significantly higher than those obtained with the crop received linuron as afalon 50 WP @ 0.750 Kg. a.i./ha for weed management.

4.2 Experiment in Conserved Residual Moisture Soil

Effect of spacing, method of nitrogen application and weed management on growth and productivity of mustard in conserved residual moisture. soil.

4.2.1 Variation in growth attributes

4.2.1.1 Leaf area index

Observation on leaf area index recorded at 20, 40, 60 and 80 DAS during the two years of experimentation had been statistically analysed and presented in table 4.14. The leaf area index of the crop increased steadily upto 60 DAS, then it declined rapidly as the crop progressed towards its maturity. The highest value of leaf area index (5.45) was recorded at 60 DAS of the crop when N was given through the second method of application (60 Kg N/ha, supplied half as basal and remaining half as foliar sprays in 30, 45 and 60 DAS). The lowest value in leaf area index at all the growth stages were recorded from the crop which has grown on higher level of spacing. The results clearly indicated that rainfed mustard should be given the closer spacing so that the utilization of moisture will be effective for its better foliage production which in term helps in improving growth and productivity of the crop.

The leaf area indices recorded at all the growth stages (20, 40, 60 and 80 DAS) during both the years increased significantly due to closer level of spacing. The LAI of 60 DAS was influenced significantly through closer spacing over higher spacings (Fig. 4.12).

Among the different methods of nitrogen application higher LAI values were obtained with the application of 60 Kg N/ha, supplied half as basal and remaining half as foliar sprays in three splits (30, 45 and 60 DAS) in all the growth stages during both the years as well as in pooled.

Pendimethalin shows its effectivity over linuron as an weed managing treatment on increasing the LAI values of the crop in all the growth stages during both the years of experimentation as well as in pooled. So, from the data its reveals that by suppressing the weeds effectively pendimeth...n helps in better foliage production of

Table 4.14 Effect of spacing, method of N application and weed management on leaf area index (LAI) at different stages of rainfed mustard

Treatment	LAI at 20 DAS			LAI at 40 DAS			LAI at 60 DAS			LAI at 80 DAS		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Poole
Spacing level												
S_1	0.19	0.19	0.19	1.14	1.13	1.13	4.79	4.82	4.80	1.66	1.68	1.67
S_2	0.24	0.25	0.24	1.51	1.37	1.44	5.19	5.32	5.25	1.80	1.76	1.78
S.Em (±)	0.002	0.001	0.001	0.011	0.011	0.007	0.015	0.007	0.008	0.010	0.011	0.00[illegible]
C.D. at 5%	0.005	0.003	0.003	0.032	0.032	0.022	0.045	0.022	0.025	0.030	0.033	0.02[illegible]
Method of N application												
M'_1	0.20	0.20	0.20	1.20	1.06	1.13	4.62	4.73	4.68	1.61	1.51	1.56
M'_2	0.24	0.25	0.25	1.55	1.49	1.52	5.37	5.45	5.41	2.03	2.01	2.02
M'_3	0.21	0.21	0.21	1.23	1.20	1.21	4.98	5.02	5.00	1.56	1.64	1.60
S.Em (±)	0.002	0.001	0.001	0.013	0.013	0.009	0.019	0.009	0.010	0.012	0.014	0.00[illegible]
C.D. at 5%	0.007	0.004	0.004	0.040	0.039	0.027	0.056	0.028	0.030	0.036	0.041	0.02[illegible]
Weed management												
W'_1	0.20	0.20	0.20	1.20	1.10	1.15	4.79	4.89	4.84	1.68	1.63	1.65
W'_2	0.23	0.24	0.24	1.46	1.40	1.43	5.19	5.24	5.21	1.78	1.80	1.79
S.Em (±)	0.002	0.001	0.001	0.011	0.011	0.007	0.015	0.007	0.008	0.017	0.011	0.00[illegible]
C.D. at 5%	0.005	0.003	0.003	0.032	0.032	0.022	0.045	0.022	0.025	0.030	0.033	0.02[illegible]
C.V. %	13.91	12.46	13.25	13.57	13.72	13.64	11.33	12.66	11.04	12.51	12.81	12.6[illegible]

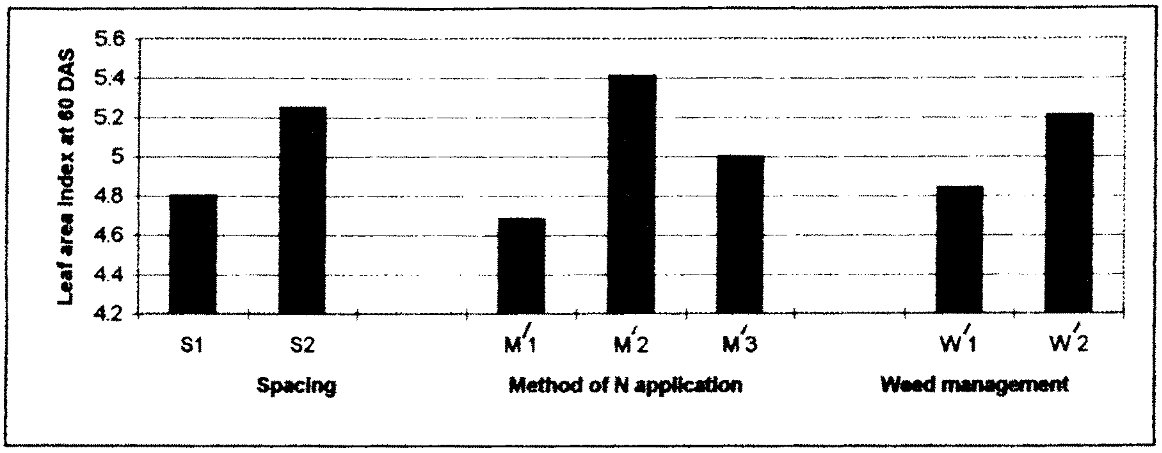

Fig. 4.12 Spacing, method of N application and weed management on LAI at 60 DAS of rainfed mustard

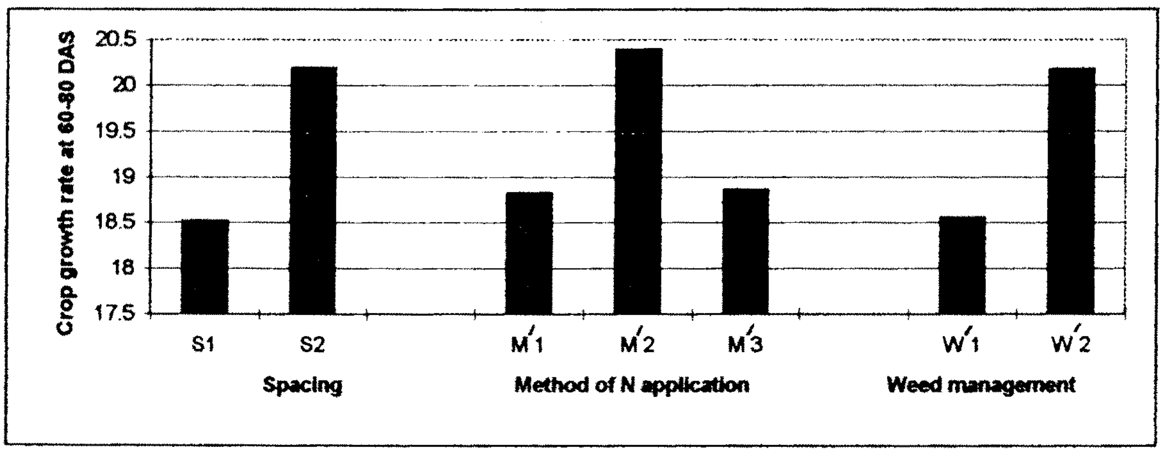

Fig. 4.13 Spacing, method of N application and weed management on CGR at 60 - 80 DAS of rainfed mustard

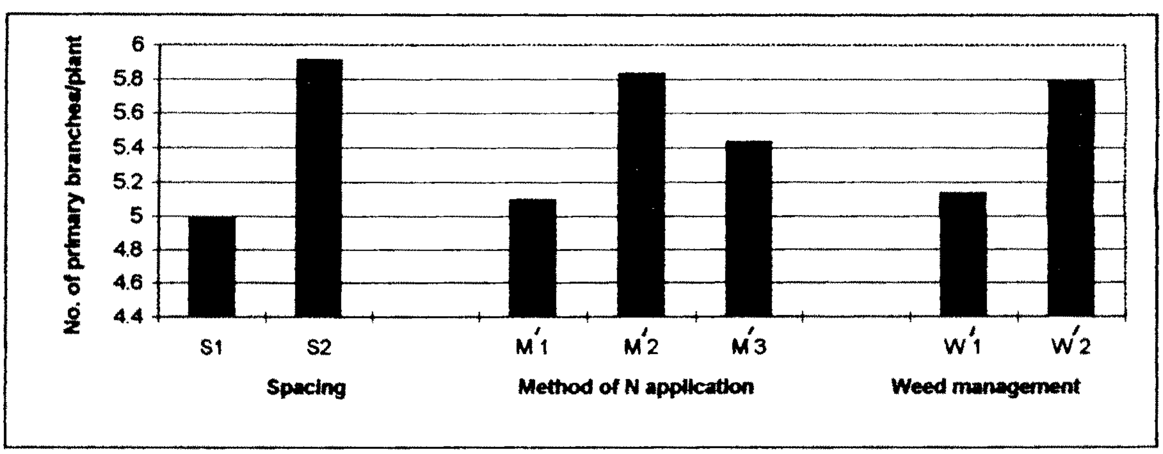

Fig. 4.14 Spacing, method of N application and weed management on no. of primary branches/plant of rainfed mustard

mustard which should help in increasing the photosynthates and ultimately the higher yield.

Interaction effect of levels of spacing, methods of N application and weed managing treatments in improving the LAI values of rainfed mustard were found significant in all the stages under study in both the years as well as in pooled except at 40 DAS stage of 1996-97 and 80 DAS stage of 1995-96 (Appendix table 2.3, 2.4, 2.5 and 2.6).

4.2.1.2 Crop growth rate

The crop growth rates estimated during the periods of 20-40 DAS, 40-60 DAS and 60-80 DAS of the rainfed crop during the two years of experimentation had been statistically analysed and presented in table 4.15.

It was observed that CGR gradually increased upto the siliqua development stage during both the years of experimentation. Closer spacing increased the CGR significantly over higher spacing at all the growth stages (20-40 DAS, 40-60 DAS and 60-80 DAS) during both the years as well as in pooled. However, closer and higher spacing were found significant during all the growth stages of the rainfed crop in both the years (Fig. 4.13).

During all the growth stages the highest CGR values were obtained with the application of 60 Kg/ha of N supplied half as basal and remaining half through foliar spraying at 30, 45 and 60 DAS. The differences in CGR values, among the crops receiving N in different methods of application were also found significant.

The data also clearly indicates that pendimethalin (Stomp 30 EC @ 1.0 Kg a.i./ha) significantly shows its effectively over linuron (Afalon 50 WP @ 0.750 Kg.a.i./ha) in influencing the CGR values of the crop through managing the weeds effectively in all the growth stages of the crop during both the years as well as in pooled.

The interaction effect of levels of spacing and method of N application were found significant on influencing the CGR values of rainfed mustard in 20-40 DAS and

Table 4.15 Effect of spacing, method of N application and weed management on crop growth rate (g m^{-2} day^{-1}) at different stages of rainfed mustard

Treatment	CGR (20-40 DAS)			CGR (40-60 DAS)			CGR (60-80 DAS)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Spacing Level									
S_1	9.29	9.40	9.35	13.40	13.59	13.5	18.21	18.83	18.52
S_2	9.87	9.91	9.89	14.54	14.62	14.58	19.80	20.58	20.19
S.Em (±)	0.27	0.02	0.01	0.04	0.04	0.02	0.25	0.05	0.13
C.D. at 5%	0.08	0.07	0.05	0.10	0.12	0.08	0.76	0.17	0.38
Method of N application									
M'_1	9.33	9.32	9.32	13.37	13.67	13.52	18.51	19.12	18.82
M'_2	9.75	10.06	9.90	14.59	14.66	14.62	20.04	20.75	20.39
M'_3	9.67	9.59	9.63	13.96	14.00	13.98	18.47	19.25	18.86
S.Em (±)	0.03	0.02	0.02	0.04	0.05	0.03	0.31	0.07	0.16
C.D. at 5%	0.10	0.08	0.06	0.13	0.15	0.10	0.93	0.21	0.46
Weed management									
W'_1	9.41	9.46	9.44	13.53	13.73	13.63	18.20	18.89	18.55
W'_2	9.75	9.83	9.80	14.42	14.49	14.45	19.82	20.52	20.17
S.Em (±)	0.03	0.02	0.01	0.04	0.04	0.02	0.25	0.05	0.13
C.D. at 5%	0.08	0.07	0.05	0.10	0.12	0.08	0.76	0.17	0.38
C.V. %	12.20	13.01	12.11	11.08	12.27	12.18	13.77	12.24	12.11

Table 4.16 Interaction effects between spacing, method of N application and weed management on crop growth rate (g m^{-2} day^{-1}) at 60 - 80 DAS of rainfed mustard

Method of N application →		1995-96				1996-97				Pooled			
Spacing & weed management ↓		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	17.99	17.74	17.50	**17.57**	18.26	18.16	18.20	**18.20**	17.87	17.95	17.85	**17.89**
	W'_2	18.11	20.36	18.11	**18.86**	18.22	21.49	18.68	**19.46**	18.16	20.92	18.39	**19.16**
	Mean	**17.80**	**19.05**	**17.80**	**18.21**	**18.24**	**19.82**	**18.44**	**18.83**	**18.02**	**19.43**	**18.12**	**18.52**
S_2	W'_1	18.16	20.26	18.07	**18.83**	18.62	21.45	18.69	**19.58**	18.39	20.85	18.38	**19.20**
	W'_2	20.31	21.86	20.22	**20.78**	21.39	21.92	21.46	**21.59**	20.85	21.86	20.84	**21.18**
	Mean	**19.23**	**21.03**	**19.14**	**19.80**	**20.00**	**21.68**	**20.07**	**20.58**	**19.62**	**21.36**	**19.62**	**20.19**
($S_1 + S_2$)	W'_1	17.82	19.00	17.78	18.20	18.44	19.80	18.44	**18.89**	18.13	19.40	18.11	**18.55**
	W'_2	19.21	21.08	19.16	**19.82**	19.80	21.70	20.07	**20.52**	19.50	21.39	19.61	**20.17**
	Mean	**18.51**	**20.04**	**18.47**	**19.01**	**19.12**	**20.75**	**19.25**	**19.71**	**18.82**	**20.39**	**18.86**	**19.36**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	0.258	0.758	0.057	0.169	0.132	0.380
M'	0.316	0.929	0.070	0.207	0.162	0.463
S x M'	0.448	NS	0.099	NS	0.229	NS
W'	0.258	0.758	0.057	0.169	0.132	0.380
S x W'	0.365	NS	0.081	NS	0.187	NS
M' x W'	0.448	NS	0.099	NS	0.229	NS
S x M' x W'	0.633	NS	0.141	NS	0.324	NS
CV %	13.77		12.24		13.11	

40-60 DAS stage but it was not significant in 60-80 DAS stage in both the years and their pooled (Table 4.19 and appendix table 2.7 and 2.8). The interaction effect of levels of spacing and weed management on influencing the CGR values of mustard were found not significant in all the stages under study in 1995-96 and 1996-97. The interaction effect on method of N application and weed management was found significant in 20-40 DAS stage but it was not significant in 40-60 DAS and 60-80 DAS stage in both the years. The interaction effect between levels of spacing, method of N application and weed management on influencing the CGR values of rainfed mustard was found significant at all the growth periods under study except at 60-80 DAS periods of 1995-96. At 60-80 DAS stage, the higher CGR values were obtained when the crop has got closer spacing (25 x 15cm), pendimethalin as weed managing treatment and 60 Kg/ha of N supplied half as basal and remaining half through foliar spary at 15, 30 and 45 DAS.

4.2.1.3 Net assimilation rates

The net assimilation rates estimated during the periods of 20-40 DAS, 40-60 DAS and 60-80 DAS of the rainfed mustard crop during the two years of experimentation had been statistically analysed and presented in table 4.17.

The results showed that closer spacing (25 x 15 cm) increased the NAR values significantly over higher spacing (30 x 15 cm) at all the growth stages under study in 1995-96, 1996-97 and their pooled.

Among the different methods of N application during all the growth stages the higher NAR values were obtained with the application of N (60 Kg/ha) half as basal and remaining half through foliar spraying in three different splits (15, 30 and 45 DAS). The differences in NAR values due to the different methods of N application were found significant in all the growth stages under study during both the years of experimentation as well as in pooled.

Pendimethalin proves its effectivity over linuron at all the growth stages (20-40 DAS, 40-60 DAS and 60-80 DAS) on influencing the NAR values of mustard.

Table 4.17 Effect of spacing, method of N application and weed management on net assimilation rate (g m^{-2} day^{-1}) at different stages of rainfed mustard

Treatment	NAR (20-40 DAS)			NAR (40-60 DAS)			NAR (60-80 DAS)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Spacing Level									
S_1	17.72	18.13	17.93	5.31	5.49	5.40	6.19	6.35	6.27
S_2	14.48	15.27	14.87	4.90	5.02	5.96	6.20	6.34	6.27
S.Em (±)	0.07	0.06	0.05	0.02	0.04	0.02	0.08	0.08	0.05
C.D. at 5%	0.23	0.18	0.14	0.06	0.12	0.07	0.24	0.24	0.30
Method of N application									
M'_1	17.36	18.19	17.78	5.33	5.59	5.46	6.47	6.61	6.54
M'_2	14.23	14.97	14.60	4.81	4.94	4.87	5.84	6.04	5.94
M'_3	16.71	16.94	16.83	5.18	5.24	5.21	6.28	6.38	6.33
S.Em (±)	0.09	0.07	0.06	0.02	0.05	0.02	0.10	0.10	0.07
C.D. at 5%	0.29	0.22	0.18	0.08	0.02	0.08	0.03	0.31	0.21
Weed management									
W'_1	17.18	18.03	17.61	5.25	5.42	5.34	6.14	6.37	6.26
W'_2	15.02	15.37	15.19	4.97	5.09	5.03	6.25	6.31	6.28
S.Em (±)	0.07	0.06	0.05	0.02	0.04	0.02	0.08	0.08	0.05
C.D. at 5%	0.23	0.18	0.14	0.06	0.12	0.07	0.24	0.24	0.30
C.V. %	12.09	14.57	13.84	11.83	13.41	12.76	12.73	12.72	12.72

The interaction effects between levels of spacing, method of N application and weed management on influencing the NAR values of mustard were found not significant in 1995-96, 1996-97 and pooled.

4.2.2 Variation in yield components

4.2.2.1 Height of the plants

Data recorded on height of the plants at maturity during the experimentation of 1995-96, 1996-97 and average of this two years (Pooled) were statistically analysed and presented in table 4.18.

The results of the experiment indicated that the plant height at maturity steadily influenced due to levels of spacing in both the years of experimentation and their pooled. Lower spacing significantly increase the plant height by 7.56% and 7.78% over higher spacing in 1995-96 and 1996-97 respectively. However, the treatment differences were not significant. Though the treatment differences were not significant The height of the rainfed mustard plant influenced steadily with different methods of nitrogen application. Highest plant height was obtained with the application of 60 Kg N/ha supplied half as basal and remaining half through foliar sprays at 15, 30 and 45 DAS. It was also revealed from the table (4.18) that lower dose of N (30Kg/ha) applied fully through foliar sprays gave higher plant height than higher N level (60Kg/ha) supplied fully as basal only. Better effect of split application of N was also reported by Mondal and Gaffer, 1983; Berti and Mosca, 1987.

Among the weed managing treatments, the influence of pendimethalin (Stomp 30 EC @ 1.0 Kg a.i./ha) on plant height was not significantly higher than linuron (Afalon 50 WP @ 0.750 Kg a.i./ha) in both the years of experimentation as well as in pooled data. Though pendimethalin increases the plant height by 6.09% and 6.31% over linuron through better management of weeds in 1995-96 and 1996-97 respectively, but it was not appreciable.

The interaction effects between levels of spacing and method of N application; levels of spacing and weed management; method of N application and weed management; levels of spacing, method of N application and weed management on

Table 4.18 Effect of spacing, method of N application and weed management on plant height, no. of primary branches per plant and no. of secondary branches per plant of rainfed mustard

Treatment	Plant height (cm)			No. of primary branches/plant			No. of secondary branches/plant		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Spacing Level									
S_1	126.93	129.80	128.37	4.72	5.26	4.99	6.15	6.85	6.50
S_2	136.53	139.91	138.22	5.63	6.20	5.91	7.17	7.97	7.57
S.Em (±)	0.31	0.34	0.23	0.04	0.05	0.03	0.04	0.06	0.03
C.D. at 5%	NS	NS	NS	0.13	0.15	0.10	0.14	0.17	0.11
Method of N application									
M'_1	126.25	130.45	128.35	4.87	5.31	5.09	6.23	6.89	6.56
M'_2	138.19	140.20	139.19	5.58	6.08	5.83	7.25	7.65	7.45
M'_3	130.76	133.92	132.34	5.08	5.79	5.43	6.51	7.68	7.09
S.Em (±)	0.38	0.42	0.28	0.05	0.06	0.04	0.05	0.07	0.04
C.D. at 5%	NS	NS	NS	0.16	0.19	0.12	0.17	0.22	0.14
Weed management									
W'_1	127.87	130.73	129.30	4.80	5.45	5.13	6.28	7.16	6.72
W'_2	135.60	138.98	137.29	5.55	6.00	5.78	7.05	7.66	7.35
S.Em (±)	0.31	0.34	0.23	0.04	0.05	0.03	0.04	0.06	0.03
C.D. at 5%	NS	NS	NS	0.13	0.15	0.10	0.14	0.18	0.11
C.V. %	11.01	11.08	11.05	13.61	13.90	13.78	12.96	13.50	13.27

Table 4.19 Interaction effects between spacing, method of N application and weed management on plant height (cm) of rainfed mustard

Method of N application →		1995-96				1996-97				Pooled			
Spacing & weed management ↓		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	116.37	125.53	125.83	**122.57**	121.90	127.63	128.30	**125.94**	119.13	126.58	127.06	**124.26**
	W'_2	121.60	142.43	129.86	**131.30**	125.26	143.23	132.50	**133.66**	123.43	142.83	131.18	**132.48**
	Mean	**118.98**	**133.98**	**127.85**	**126.93**	**123.58**	**135.43**	**130.40**	**129.80**	**121.28**	**134.70**	**129.12**	**128.37**
S_2	W'_1	130.13	139.60	129.76	**133.16**	132.46	142.23	131.90	**135.53**	131.30	140.91	130.83	**134.35**
	W'_2	136.93	145.20	137.60	**139.91**	142.20	147.70	143.00	**144.30**	139.56	146.45	140.30	**142.10**
	Mean	**133.53**	**142.44**	**133.68**	**136.53**	**137.33**	**144.90**	**137.45**	**139.90**	**135.43**	**143.68**	**135.56**	**138.22**
($S_1 + S_2$)	W'_1	123.25	132.56	127.80	127.87	127.18	134.93	130.10	**130.73**	125.21	133.75	128.95	**129.30**
	W'_2	129.26	143.81	133.73	**135.60**	133.73	145.46	137.75	**138.98**	131.50	144.64	135.74	**137.29**
	Mean	**126.25**	**138.19**	**130.76**	**131.73**	**130.45**	**140.20**	**133.92**	**134.86**	**128.35**	**139.19**	**132.34**	**133.30**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	0.313	NS	0.344	NS	0.232	NS
M'	0.384	NS	0.421	NS	0.285	NS
S x M'	0.548	NS	0.596	NS	0.403	NS
W'	0.313	NS	0.344	NS	0.232	NS
S x W'	0.443	NS	0.486	NS	0.329	NS
M' x W'	0.543	NS	0.596	NS	0.403	NS
S x M' x W'	0.768	NS	0.843	NS	0.570	NS
CV %	11.01		11.08		11.05	

influencing the height of the plant were found not significant in both the years as well as in their pooled (Table 4.19).

4.2.2.2 Number of primary branches per plant

The data on the production of primary branches per plant were recorded at maturity during both the years of experimentation and were statistically analysed and presented in table 4.18.

The results showed that the no. of primary branches per plant influenced significantly due to levels of spacing during both the years as well as in their pooled (Fig. 4.14). The higher no. of primary branches per plant was produced significantly due to closer spacing which were 19.2% and 17.8% higher than that of higher spacing given to the rainfed mustard plants in 1995-96 and 1996-97 respectively. Similar results were also obtained by Patel *et al.*, 1980; Shaik Khader and Bhargava, 1985 and Singh and Singh, 1987.

The number of primary branches per plant increase significantly with the methods of N application in both the years of experimentation as well as in pooled. The highest no. of primary branches per plant (5.58 and 6.08 in 1995-96 and 1996-97 respectively) were observed when 60 Kg N/ha was applied half as basal dose and remaining half (30 Kg N/ha) through foliar spray in 15, 30 and 450 DAS. Lower level of N (30 Kg/ha) supplied only through foliar sprays gave significantly higher no. of primary branches per plant than when applied higher dose of N (60 Kg/ha) fully as basal.

The table also clearly indicated that pendimethalin (Stomp 30 EC @ 1.0 Kg.a.i./ha) significantly increases the no. of primary branches per plant by 15.62% and 10.09% over linuron (Afalon 50 WP @ 0.750 Kg a.i./ha) through better management of weeds infested in the rainfed mustard field during 1995-96 and 1996-97 respectively.

The interaction effect of levels of spacing and method of N application was found significant on influencing the production of primary branches per plant during 1995-96, 1996-97 and pooled. The interactive effect of levels of spacing, method of N application and weed management was found significant for influencing the no. of primary branches per plant in 1995-96 and pooled but not in 1996-97. However, the interaction effects between levels of spacing and weed management; method of N application and weed management were found not significant in 1995-96, 1996-97 and pooled (Appendix table 2.1).

4.2.2.3 Number of secondary branches per plant

The data on the production of secondary branches per plant were recorded at maturity during both the years of experimentation and were statistically analysed and depicted in table 4.18.

The results showed that the no. of secondary branches per plant influenced significantly due to levels of spacing during both the years. The higher no. of secondary branches per plant were produced due to closer spacing over higher spacing. The percentage increase being 16.58, 16.35 and 16.46 during 1995-96, 1996-97 and pooled respectively.

The maximum no. of effective secondary branches per plant were recorded from the crop receiving 60 Kg/ha of nitrogen, supplied half (30 Kg/ha) as basal and remaining half through foliar sprays. Though the no. of secondary branches per plant differ significantly among the different methods of N application but the difference were not much. Lower dose of N (30 Kg/ha) supplied fully through foliar sprays also gave better result than that of the crop receiving higher dose of N (60 Kg/ha) supplied fully as basal.

The no. of secondary branches per plant was influenced favourably by the application of herbicides through different chemicals during 1995-96, 1996-97 and their pooled data. Higher no. of secondary branches per plant were produced due to the effect of pendimethalin (Stomp 30 EC @ 1.0 Kg.a.i./ha) over linuron (Afalon 50 WP @ 0.750 Kg a.i./ha). It proves the effectivity of pendimethalin over linuron in management of weeds infested in the rainfed mustard field (Fig. 4.15).

The interaction effect between levels of spacing, method of N application and weed management on influencing the no. of secondary branches per plant was found

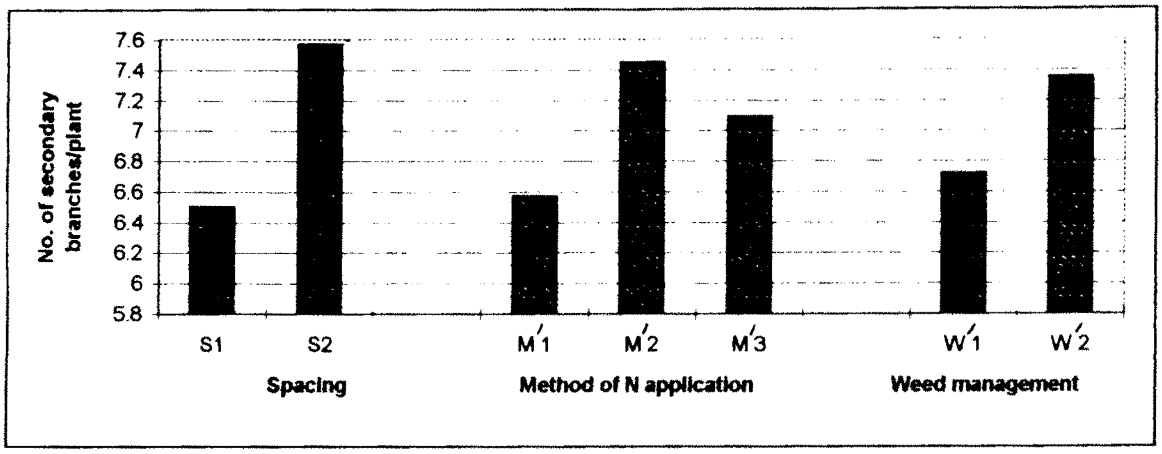

Fig. 4.15 Spacing, method of N application and weed management on no. of secondary branches/plant of rainfed mustard

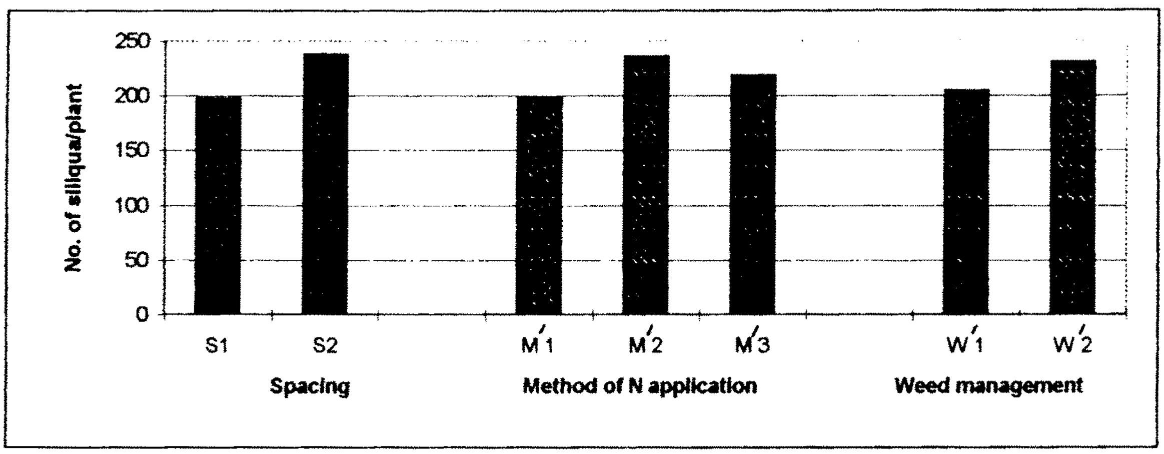

Fig. 4.16 Spacing, method of N application and weed management on no. of siliqua/plant of rainfed mustard

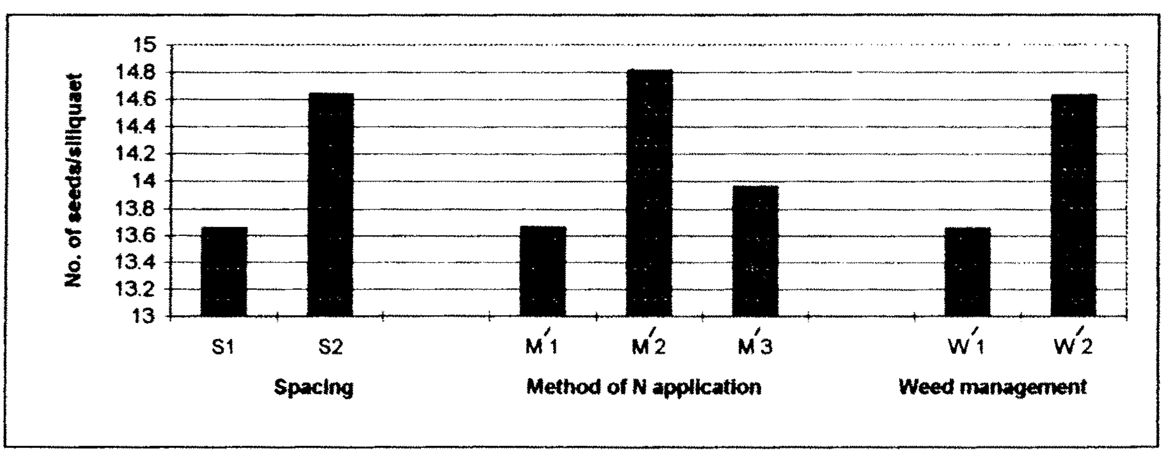

Fig. 4.17 Spacing, method of N application and weed management on no. of seeds/siliquae of rainfed mustard

significant in both the years of experimentation as well as in pooled (Appendix table 2.2).

4.2.2.4 Number of siliqua per plant

The data recorded on no. of siliqua per plant at maturity during 1995-96, 1996-97 and their pooled were statistically analysed and presented in table 4.20.

The results showed that crop grows on closer spacing produced significantly greater no. of siliqua per plant than those of the crop grows on higher spacing. Closer spacing produced 20.93, 20.08 and 20.49 percent higher no. of siliqua per plant than those of the crops grows with larger spacing in 1995-96, 1996-97 and pooled respectively. Significant increase in no. of siliqua per plant with closer to higher spacing were also reported by Patel *et al.*, 1980 and Shaik Khader and Bhargava, 1985.

The no. of siliqua per plant increased significantly with the different methods of N application. The highest no. of siliqua per plant was observed with the application of 60 Kg/ha of N supplied half as basal and remaining half through foliar spraying at three different splits (15, 30 and 45 DAS) during both the years of experimentation and their pooled. However, higher dose of N (60 Kg/ha) when applied only as basal produced lower no. of siliqua per plant than lower dose of N (30 Kg/ha) applied only through foliar spray (Fig. 4.16).

The data also clearly indicated that pendimethalin (Stomp 30 EC @ 1.0 Kg a.i./ha) produced 13.21, 12.28 and 12.74 percent increased no. of siliqua per plant over linuron (Afalon 50 WP @ 0.750 Kg a.i./ha) through better management of weeds in rainfed mustard field in 1995-96, 1996-97 and pooled and these increase were significant also.

The interaction effects of levels of spacing and method of N application; levels of spacing, method of N application and weed management on influencing the no. of siliqua per plant were found significant in both the years as well as in pooled. But the interaction effects between levels of spacing and weed management; methods of N application and weed management were found not significant in both the years of experimentation (Appendix table 2.9).

Table 4.20 Effect of spacing, method of N application and weed management on no. of siliqua per plant, no. of seeds per siliquae and test weight (g) of rainfed mustard

Treatment	No. of siliqua/plant			No. of seeds/siliquae			Test weight (g)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Spacing Level									
S_1	192.61	201.48	197.05	13.65	13.65	13.65	3.55	3.57	3.56
S_2	232.93	241.95	237.44	14.53	14.74	14.64	3.90	3.91	3.90
S.Em (±)	1.17	1.09	0.80	0.06	0.05	0.04	0.02	0.01	0.01
C.D. at 5%	3.43	3.21	2.30	0.20	0.17	0.13	NS	NS	NS
Method of N application									
M'_1	193.77	201.35	197.56	13.60	13.72	13.66	3.56	3.59	3.58
M'_2	230.49	240.82	235.65	14.73	14.89	14.81	3.91	3.91	3.91
M'_3	214.04	222.97	218.51	13.95	13.97	13.96	3.70	3.73	3.72
S.Em (±)	1.43	1.34	0.98	0.08	0.07	0.05	0.026	0.01	0.01
C.D. at 5%	4.20	3.93	2.82	0.24	0.21	0.16	NS	NS	NS
Weed management									
W'_1	199.58	208.88	204.23	13.61	13.69	13.65	3.58	3.62	3.60
W'_2	225.96	234.54	230.25	14.57	14.70	14.63	3.87	3.86	3.87
S.Em (±)	1.17	1.09	0.80	0.06	0.05	0.04	0.02	0.01	0.01
C.D. at 5%	3.43	3.21	2.30	0.20	0.17	0.13	NS	NS	NS
C.V. %	12.34	12.10	12.22	12.03	13.72	12.88	12.42	14.42	13.98

4.2.2.5 Number of seeds per siliquae

The data recorded on no. of seeds per siliquae at harvest during 1995-96, 1996-97 and pooled were statistically analysed and presented in table 4.20.

The results showed that crops grown on closer spacing produced significantly greater no. of seeds per siliquae than those of the crops grown on higher spacing. Closer spacing produced 6.44, 7.98 and 7.25 percent of higher no. of seeds per siliquae than those of higher spacing in 1995-96, 1996-97 and pooled respectively. Significant increase in no. of seeds per siliquae with closer to higher spacing were also observed by Shaik Khader and Bhargava, 1985 and Singh and Singh, 1987.

From the data it also reveals that, no. of seeds per siliquae increased considerably due to the methods of N application during both the years of study (Table 4.21). Seeds per siliquae increased steadily and significantly as methods of N application changed in both the years as well as in pooled. The highest no. of seeds per siliquae was noticed in crop grown at high level of N (60 Kg/ha) supplied half as basal and remaining half through foliar spraying in three different splits (15, 30 and 45 DAS). It was followed by the crop raised with lower N level (30 Kg/ha) supplied fully through foliar spraying. It was interesting to note that crop receiving lower level of N (30Kg/ha) fully through foliar sprays produced more no. of seeds per siliquae than those obtained with comparatively higher dose of N (60 Kg/ha) supplied only as basal application during both the years and in pooled (Fig. 4.17).

The data clearly indicated that pendimethalin significantly showed its effectivity over linuron on influencing the production of seeds per siliquae of the crop through suppressing the weeds effectively during both the years as well as in pooled. The crop received pendimethalin as weed managing treatment produced 7.05, 7.37 and 7.17 per cent more no. of seeds per siliquae than those received linuron during 1995-96, 1996-97 and in pooled respectively.

The interaction effect of levels of spacing, method of N application and weed management was found significant on influencing the no. of seeds per siliquae in 1995-96, 1996-97 and pooled. However, the interaction effects of levels of spacing and methods of N application; methods of N application and weed management was found significant occasionally and the interactive effect of levels of spacing and weed managing treatments was found not significant in both the years under study and their pooled (Appendix table 2.10).

4.2.2.6 Test weight of grain (1000-seed weight)

The test weight of rainfed mustard grain recorded at maturity during 1995-96, 1996-97 and pooled were statistically analysed and presented in table 4.20.

The result revealed that the crop grown on closer spacing produced higher test weight than the crops grown on ~~higher~~ wider spacing but the difference between these two were found not significant in both the years of study.

Different methods of N application did not cause~~d~~ marked influence on increasing the test weight of rainfed mustard grain during both the years under study (Table 4.20). However the trend was the Crops receiving N (60 Kg/ha) half as basal and remaining half through foliar spraying increased the test weight over those received N at the dose of 60 Kg/ha of N only through foliar sprayings.

The data clearly indicates that pendimethalin did not showe~~d~~ its effectivity over linuron on influencing the 1000-grain weight of rainfed mustard through managing the weeds effectively during both the years as well as in pooled data. The percentage increase were 8.10 and 6.62 in 1995-96 and 1996-97 respectively and not appreciable.

The interaction effect between levels of spacing and method of N application; levels of spacing and weed managing treatments; method of N application and weed managing treatment; levels of spacing, method of N application and weed management treatment towards test weight of rainfed mustard was found not significant in 1995-96, 1996-97 and their pooled.

4.2.3 Variation in crop productivity

4.2.3.1 Seed yield

Seed yield of rainfed mustard recorded at maturity from the individual plots receiving different treatments during 1995-96, 1996-97 and their pooled data were statistically analysed and presented in table 4.21.

Table 4.21 Effect of spacing, method of N application and weed management on seed yield (kg/ha), stover yield (kg/ha), harvest index, oil content (%) and oil yield (kg/ha) of rainfed mustard

Treatment	Seed yield (kg/ha)			Stover yield (kg/ha)			Harvest index			Oil content (%)			Oil yield (kg/ha)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Spacing level															
S_1	797.50	899.88	848.69	2627.56	2919.66	2773.61	22.95	23.31	23.13	38.70	38.70	38.70	309.72	349.48	329.62
S_2	1062.05	1163.55	1112.80	2945.46	3352.63	3149.04	26.38	25.45	25.92	39.61	39.71	39.66	421.59	462.52	442.06
S.Em (±)	5.91	6.01	4.21	9.43	7.92	6.16	0.14	0.19	0.12	0.08	0.07	0.05	2.48	2.42	1.73
C.D. at 5%	17.33	17.66	12.10	27.66	23.24	17.68	0.417	0.584	0.351	NS	NS	NS	7.28	7.11	4.98
Method of N application															
M'_1	801.66	911.33	856.50	2612.95	3031.50	2822.23	22.99	22.79	22.89	38.70	38.82	38.76	312.48	355.56	334.02
M'_2	1062.66	1164.58	1113.62	2970.94	3289.89	3130.41	26.13	25.98	26.06	39.63	39.61	39.62	422.05	462.48	442.26
M'_3	925.00	1019.25	972.12	2775.64	3087.05	2931.35	24.87	24.38	25.63	39.15	39.20	39.17	362.51	399.96	381.24
S.Em (±)	7.24	7.36	5.16	11.55	9.70	7.54	0.17	0.24	0.15	0.10	0.08	0.06	3.04	2.96	2.12
C.D. at 5%	21.22	21.57	14.82	33.88	28.47	21.65	0.512	0.715	0.430	NS	NS	NS	8.92	8.70	6.10
Weed management															
W'_1	835.27	936.94	886.11	2693.96	3066.08	2880.02	23.39	22.98	23.19	38.93	38.91	38.95	326.30	366.36	346.33
W'_2	1024.27	1126.50	1075.38	2879.06	3206.21	3042.64	25.94	25.78	25.86	39.39	39.44	39.41	405.06	445.64	425.35
S.Em (±)	5.91	6.01	4.21	9.43	7.92	6.16	0.14	0.19	0.15	0.08	0.07	0.05	2.48	2.42	1.73
C.D. at 5%	17.33	17.61	12.10	27.66	23.24	17.68	0.417	0.584	0.351	NS	NS	NS	7.28	7.11	4.98
C.V. %	12.70	13.47	12.58	10.44	11.07	11.25	12.45	13.47	13.00	8.94	8.77	9.86	12.88	14.53	13.70

The results showed that crops grown on closer spacing (25 x 15 cm) produced significantly greater seed yield (1112.80 Kg/ha according to pooled data) than those of the crops grown on higher spacing (848.69 Kg/ha according to pooled data). Closer spacing produced 33.17 and 29.30 percent higher seed yield than higher spacing in 1995-96 and 1996-97 respectively. The beneficial effect of closer spacing in case of rainfed mustard had been highlighted by many workers (Patel *et al.,* 1980; Shaik Khader and Bhargava, 1985; Singh and Singh, 1987 and Gupta, 1988).

The result showed very high response of rainfed mustard to the applied nitrogen (Table 4.21). Seed yield increased steadily and significantly due to the application of N either through basal, foliar, half basal-half foliar methods during both the years of experimentation and their pooled (Fig. 4.18). Maximum seed yield (1062.66, 1164.58 and 1113.62 Kg/ha in 1995-96, 1996-97 and pooled respectively) was recorded in crops raised with 60 Kg of N/ha supplied half (30 Kg/ha) as basal and remaining half (30 Kg/ha) through foliar sprays in three different splits (at 15, 30 and 45 DAS). It was significantly higher than those obtained from all other nitrogen treatments under study. However, it is interesting to note that the crop receiving lower level of nitrogen (30Kg/ha), supplied only through foliar sprays recorded significantly higher seed yield than the crop received higher level of N (60 Kg/ha) supplied only through basal application. This showed the superiority of foliar sprays of N over only basal application in increasing the crop productivity. The increase in seed yield due to application of N through split doses were also evidenced by Lahiri and De, 1971; Gaffer and Razzaque, 1984 and Berti and Mosca, 1987.

The data clearly indicates that pendimethalin (Stomp 30 EC @ 1.0 Kg a.i./ha) has significantly higher influence on the production of seed yield than linuron (Afalon 50 WP @ 0.750 Kg a.i./ha) through better management of weeds infected in rainfed mustard field. The crop received pendimethalin as weed managing treatment produced significantly higher yield than those received linuron in both the years of experimentation as well as in pooled.

The interactive effects between levels of spacing and method of N application; method of N application and weed management; levels of spacing, method of N application and weed management though found significant towards the seed yield of

Table 4.22 Interaction effects between spacing, method of N application and weed management on seed yield (kg/ha) of rainfed musrard

Method of N application →		1995-96				1996-97				Pooled			
Spacing & weed management ↓		M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
S_1	W'_1	538.00	772.33	807.66	**706.00**	673.33	874.33	876.33	**808.00**	605.66	823.33	842.00	**757.00**
	W'_2	660.00	1122.66	884.33	**889.00**	762.00	1224.66	988.7	991.8	**711.00**	1173.66	736.50	940.38
	Mean	**599.00**	**947.00**	**846.00**	**797.50**	**717.66**	**1049.50**	**932.50**	**899.88**	**658.33**	**998.5**	**889.25**	**848.69**
S_2	W'_1	886.66	1121.66	885.33	**964.55**	986.33	1224.00	987.33	**1065.88**	936.50	1172.83	936.33	**1015.22**
	W'_2	1122.00	1234.00	112.66	**1159.55**	1223.66	1335.33	1224.66	**1261.22**	1172.83	1284.66	1173.66	**1210.38**
	Mean	**801.66**	**1062.66**	**925.00**	929.77	**911.33**	**1164.58**	**1019.25**	**1031.72**	**856.50**	**1113.62**	**972.12**	**980.75**
$(S_1 + S_2)$	W'_1	712.33	947.00	846.50	835.27	829.83	1049.16	931.83	**936.94**	771.08	998.08	889.16	**886.11**
	W'_2	891.33	1178.33	1003.50	**1024.27**	992.83	1280.00	1106.66	**1126.50**	941.91	1228.16	1055.08	**1075.38**
	Mean	**801.66**	**1062.66**	**925.00**	929.77	**911.33**	**1164.58**	**1019.25**	**1031.72**	**856.50**	**1113.62**	**972.12**	**980.75**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	5.91	17.33	6.01	17.66	4.21	12.10
M'	7.24	21.22	7.36	21.57	5.16	14.82
S x M'	10.24	30.01	10.41	30.50	7.30	20.96
W'	5.91	17.33	6.01	17.61	4.21	12.10
S x W'	8.36	NS	8.50	NS	5.96	NS
M' x W'	10.24	30.01	10.41	30.50	7.30	20.96
S x M' x W'	14.48	42.45	14.72	43.13	10.32	29.64
CV %	12.70		12.47		12.58	

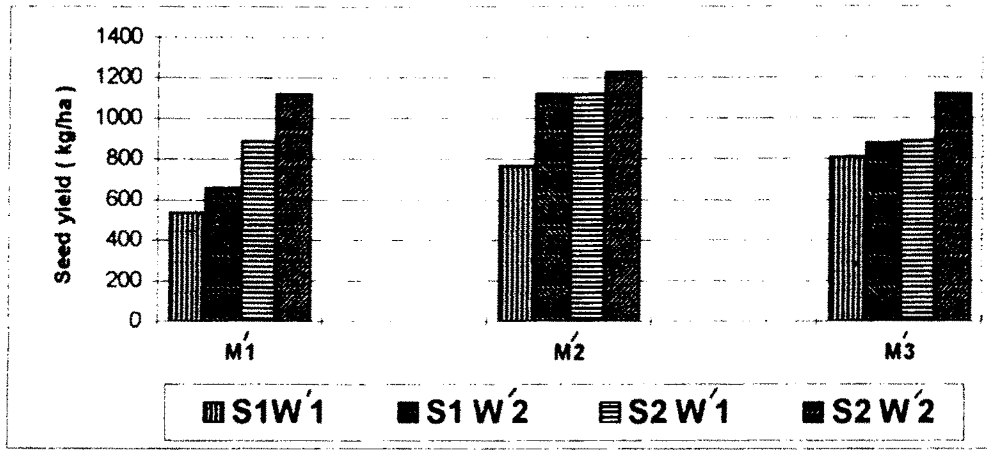

Fig. 4.18 Interaction effect of spacing, method of N application and weed management on seed yield of rainfed mustard

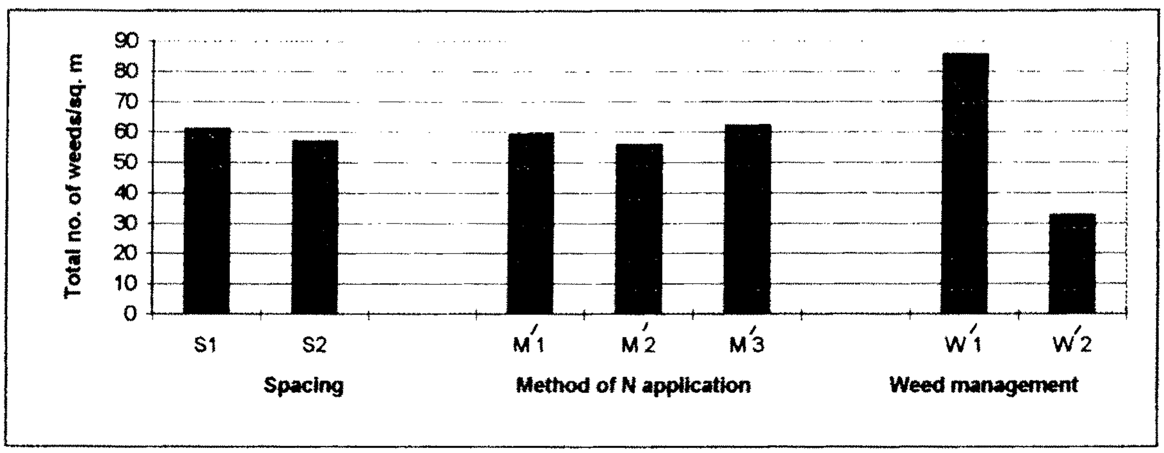

Fig. 4.19 Spacing, method of N application and weed management on total no. of weeds/sq. m of rainfed mustard

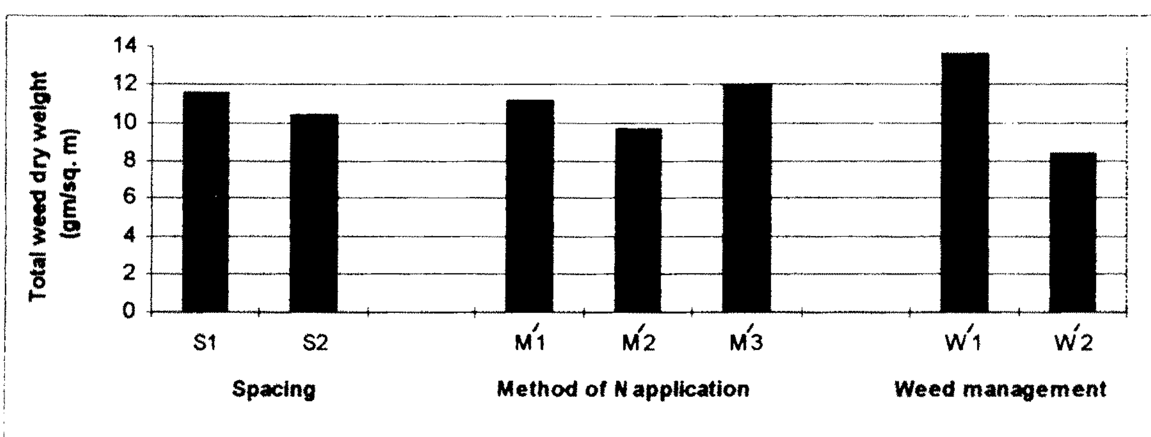

Fig. 4.20 Spacing, method of N application and weed management on total weed dry weight of rainfed mustard

rainfed mustard but the interaction effect of levels of spacing and weed management was found not significant in both the years under study as well as in pooled (Table 4.22). The highest seed yield was obtained (1234.00, 1335.33 and 1284.66 Kg/ha in 1995-96, 1996-97 and pooled respectively) when the crop grown in low spacing (25 x 15cm) with pendimethalin (Stomp 30 EC @ 1.0 Kg.a.i./ha) used as weed managing treatment and for N management, 60 Kg N/ha was supplied half (30 Kg/ha) as basal and remaining half through foliar sprays in three splits (at 15, 30 and 45 DAS).

4.2.3.2 Stover yield

The stover yield of mustard recorded at maturity during 1995-96, 1996-97 and their pooled were statistically analysed and presented in table 4.21. The result showed that the crops grown on closer spacing produced higher quantity of stover which was significantly greater than those of the crops grown on higher spacing. The results clearly indicated that rainfed mustard should provide closer spacing so that it can effectively used the reserve soil moisture to obtained better growth of the crop under this region of West Bengal.

The results further revealed that the stover yield was significantly influenced by the method of application of N during both the years of experimentation (Table 4.21). Maximum quantity of stover was produced from the plots received 60 Kg of N/ha supplied half as basal and remaining half through foliar spraying in three splits (at 15, 30 and 45 DAS) during 1995-96, 1996-97 and pooled. This was significantly superior to the stover yields obtained from all other N treatments under study.

From the data it revealed that pendimethalin in the form of Stomp 30 EC @ 1.0 Kg.a.i./ha helps in producing significantly higher stover yield than that of linuron in the form of Afalon 50 WP @ 0.750 Kg.a.i/ha during both the years. The difference between the produced quantity of stover by pendimethalin and linuron were 6.87, 4.57 and 5.64 percent in 1995-96, 1996-97 and their pooled. This clearly showed the benefit of pendimethalin over linuron in suppressing the weeds of the rainfed mustard field.

The interaction effects between levels of spacing and method of N application; levels of spacing and weed management; method of N application and weed management; levels of spacing, method of N application and weed management were found significant on influencing the stover yield of rainfed mustard in 1995-96, 1996-97 and their pooled (Appendix table 2.11). The highest amount of stover was produced with the crops grown on closer spacing (25 x 12 cm), pendimethalin as weed managing treatment and 60 Kg/ha of N supplied half as basal and remaining half through foliar sprays.

4.2.3.3 Harvest index

Harvest index estimated from grain and stover yield at maturity during 1995-96, 1996-97 and pooled were statistically analysed and presented in table 4.21.

The results showed that the crops grown on closer spacing gave the higher values of harvest index than those grown on higher spacing in both the years and their pooled. The difference in harvest index due to levels of spacing were found significant in both the years of experimentation as well as in pooled.

Harvest index of the rainfed mustard crop was influenced favourably by the different methods of nitrogen management. Significant increase in harvest index was noticed in crop receiving 60 Kg/ha of N supplied, half (30 Kg/ha) as basal and remaining half through foliar spraying in three different splits (at 15, 30 and 45 DAS) over other methods of N application. The difference in harvest indices were also significant among the different methods of N application in both the years of experimentation and their pooled.

The harvest index of rainfed mustard was influenced at varying weed managing treatments. Pendimethalin in the form of Stomp 30 EC @ 1.0 Kg.a.i/ha produced significantly higher harvest indices values over linuron (Afalon 50WP@ 0.750Kg.a.i/ha).

The interaction effects between levels of spacing and method of N application; method of N application and weed management; levels of spacing, method of N application and weed management on influencing the harvest index though found significant but the interaction effect of levels of spacing and weed management was found not significant in both the years of experimentation as well as in pooled (Appendix table 2.12). The highest value of harvest index was obtained with the crop which has grown on closer spacing, with pendimethalin as weed managing treatment and 60 Kg/ha of N supplied half (30 Kg/ha) as basal and remaining half through foliar spraying in three different splits.

4.2.3.4 Oil content

Oil content in rainfed mustard grain estimated at maturity was statistically analysed and presented in table 4.21.

The results showed that oil content did not vary much among the close and broad spacing. Slight increase in oil content was there due to change in spacing and this increase was not significant.

Nitrogen management showed slight effect on influencing the oil content in mustard grain during both the years under study (Table 4.21). Crop receiving 60 Kg/ha of N, supplied half as basal and remaining half through foliar spraying in three different splits produces 39.63 and 39.61 percent of oil in grain in 1995-96, and 1996-97 respectively. Nitrogen applied at the dose of 30 Kg/ha supplied fully through foliar spraying at 15, 30 and 45 DAS also produces higher oil content (39.15 and 39.20 percent in 1995-96 and 1996-97 respectively) in both the years of experimentation.

Similarly, the oil content of mustard did not vary much among the two weed managing treatments. The oil content increased from 38.95 to 39.41 due to the influence of pendimethalin to linuron in pooled data (Table 4.21) and also this increase was not significant in both the years and their pooled.

The interaction effect of levels of spacing and method of N application; levels of spacing and weed management; method of N application and weed management; levels of spacing, method of N application and weed management towards the oil content of rainfed mustard were found not significant in both the years under study and in pooled (Appendix table 2.13).

4.2.4 Variation in weed infestation

The data on weed population and dry weight of weeds recorded at 60 days after sowing of rainfed mustard during 1995-96, 1996-97 and their pooled were analysed and depicted in table 4.23.

4.2.4.1 Categorised weed density

The results showed that the experimental field was severely infested with sedges as compared to grasses and broadleaf weeds during both the years under study (Table 4.23). The total no. of weeds decreased steadily with the closer spacing level. Similar trend of results was also observed with the sedge weeds found in the experimental field during both the years under study. The lower no. of sedge weeds and so also the total weeds were recorded in plots given closer spacing during both the years. However, the difference in sedges, broad-leaf, grasses and total weeds between the plots given closer and higher spacings were not significant in all the years and pooled. The results clearly indicated that closer spacing in rainfed mustard (where moisture is in stressed condition) was helpful not only for improving growth and productivity of the crop but also for suppressing the weed infestation under this region of West Bengal.

The weed density did not vary much due to variation in method of nitrogen management during both the years under study (Table 4.23). Plots receiving 60 Kg/ha of N supplied half as basal and half through foliar spray showed a little bit of less weed infestation than those obtained from the plots receiving other method of nitrogen application.

The data clearly indicated that the weed population per sq.m was steadily and significantly influenced due to the application of two herbicides. Pendimethalin in the form of Stomp 30 EC @ 1.0 Kg.a.i/ha produced significantly lower no. of weeds than that of the plots received linuron (Afalon 50 WP @ 0.750 Kg.a.i/ha) as weed managing treatments. The lower no. of sedges and so also the total weeds were recorded in plots given pendimethalin as weed managing treatments (Fig. 4.19). It proves that pendimethalin was more effective in suppressing the infestation of weeds in rainfed mustard field.

The interaction effects between levels of spacing and method of N application; levels of spacing and weed management; method of N application and weed management; levels of spacing, method of N application and weed management on influencing the total weed population per sq.m were found not significant in both the years under study and their pooled (Table 4.24).

Table 4.23 Effect of spacing, method of N application and weed management on weed density and weed dry weight of rainfed mustard

Treatment	No. of grasses/sq. m			No. of sedges/sq. m			No. of broad leaved/sq. m			Total no. of weeds/sq. m			Total weed dry wt. (g/sq. m)		
	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled	1995-96	1996-97	Pooled
Spacing level															
S_1	11.68	9.88	10.78	34.38	33.30	33.84	16.98	15.63	16.31	63.05	58.80	60.92	12.31	10.82	11.56
S_2	10.70	9.65	10.17	31.36	32.00	31.68	14.60	15.53	15.06	56.67	57.17	56.92	10.35	10.38	10.36
S.Em (±)	0.22	0.18	0.14	0.41	0.27	0.24	0.12	0.18	0.11	0.63	0.52	0.41	0.15	0.12	0.09
C.D. at 5%	0.67	NS	0.42	1.21	0.81	0.72	0.37	NS	0.32	1.86	NS	1.17	0.45	0.36	0.28
Method of N application															
M'_1	10.65	8.45	9.55	31.82	33.85	32.83	16.77	16.60	16.68	59.26	58.86	59.06	11.09	11.23	11.16
M'_2	11.12	10.07	10.60	31.32	30.52	34.52	16.17	16.10	16.13	56.87	54.64	55.75	12.54	11.49	12.03
M'_3	11.80	10.77	11.28	35.47	33.57	34.52	16.17	16.10	16.13	63.45	60.45	61.95	12.54	11.49	12.03
S.Em (±)	0.27	0.23	0.18	0.50	0.33	0.30	0.15	0.22	0.13	0.77	0.63	0.50	0.18	0.15	0.11
C.D. at 5%	0.82	0.68	0.52	1.49	010	0.88	0.46	0.66	0.39	2.27	NS	1.44	0.55	0.44	0.34
Weed management															
W'_1	17.36	15.26	16.31	50.05	49.83	49.94	19.76	18.65	19.21	87.18	83.72	85.45	13.94	13.17	13.56
W'_2	5.01	4.26	4.64	15.70	15.46	15.58	11.81	12.51	12.16	32.54	32.25	32.39	8.70	8.03	8.36
S.Em (±)	0.22	0.18	0.14	0.41	0.27	0.24	0.12	0.18	0.11	0.63	0.52	0.41	0.15	0.15	0.09
C.D. at 5%	0.67	0.55	0.42	1.21	0.81	0.72	0.38	0.54	0.32	1.86	1.62	1.17	0.45	0.36	0.28
C.V. %	14.65	14.17	14.47	14.37	13.59	14.57	13.42	14.98	14.26	14.50	13.81	14.18	14.70	14.93	14.35

Table 4.24 Interaction effects between spacing, method of N application and weed management on total number of weeds per sq.m of rainfed mustard

Method of N application → / Spicing & weed management ↓		1995-96				1996-97				Pooled			
		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	91.30	86.70	92.70	**90.23**	94.00	94.70	90.13	**92.94**	92.25	95.40	90.17	**92.78**
	W'_2	37.60	27.40	42.60	**35.86**	**37.70**	28.20	34.30	**33.40**	**37.25**	26.45	36.00	33.23
	Mean	**64.45**	**57.05**	**67.65**	**63.05**	**65.85**	**61.45**	**62.21**	**63.17**	**64.75**	**60.92**	**63.35**	**63.01**
S_2	W'_1	79.70	85.10	87.60	**84.13**	90.06	99.60	94.10	**94.58**	89.98	95.55	94.45	**93.32**
	W'_2	28.46	28.30	30.90	**29.22**	32.60	29.30	30.60	**30.83**	31.25	29.05	29.05	**29.78**
	Mean	**54.08**	**56.70**	**59.25**	**56.67**	**61.33**	**64.45**	**62.35**	**62.71**	**60.61**	**62.30**	**61.75**	**61.55**
($S_1 + S_2$)	W'_1	85.50	85.90	90.15	87.18	92.03	97.15	92.11	**93.76**	91.11	95.47	92.58	**93.65**
	W'_2	33.03	27.85	36.75	**32.54**	35.15	28.75	32.45	**32.11**	34.25	27.75	32.52	**31.50**
	Mean	**59.26**	**56.87**	**63.45**	**59.86**	**63.59**	**62.95**	**62.28**	**62.94**	**92.68**	**61.61**	**62.55**	**62.28**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	0.634	1.86	1.36	NS	0.410	1.17
M'	0.777	2.27	1.67	NS	0.502	1.44
S x M'	1.09	NS	2.37	NS	0.710	NS
W'	0.634	1.86	1.36	NS	0.410	1.17
S x W'	0.897	NS	1.93	NS	0.580	NS
M' x W'	1.09	NS	2.37	NS	0.710	NS
S x M' x W'	1.55	NS	3.35	NS	1.00	NS
CV %	14.50		15.23		14.18	

Table 4.25 Interaction effects between irrigation, method of N application and weed management on total weeds dry weight (gm/sq. m) of rainfed mustard

Method of N application → / Spacing & weed management ↓		1995-96				1996-97				Pooled			
		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	15.52	13.61	16.16	**15.07**	14.78	13.02	12.12	**13.30**	89.43	85.36	86.80	**87.20**
	W'_2	9.54	6.86	12.18	9.52	8.82	5.42	10.78	8.34	**35.25**	27.05	41.65	34.65
	Mean	**12.53**	**10.23**	**14.17**	**12.34**	**11.80**	**9.22**	**11.45**	**10.82**	**62.34**	**56.20**	**64.22**	**60.92**
S_2	W'_1	11.58	13.18	13.63	**12.79**	12.25	12.78	14.12	**13.05**	80.45	83.61	87.05	**83.70**
	W'_2	7.72	7.68	8.22	**7.87**	9.09	5.10	8.97	**7.72**	31.13	27.00	32.30	**30.14**
	Mean	**9.65**	**10.43**	**10.92**	**10.33**	**10.67**	**8.94**	**11.54**	**10.38**	**55.79**	**55.30**	**59.67**	**56.92**
($S_1 + S_2$)	W'_1	13.55	13.39	14.89	**13.94**	13.51	12.90	13.12	**13.17**	84.94	84.49	86.92	**85.45**
	W'_2	8.63	7.27	10.20	**8.70**	8.95	5.26	9.87	**8.03**	33.19	27.02	36.97	**32.39**
	Mean	**11.09**	**10.33**	**12.54**	**11.32**	**11.23**	**9.08**	**11.49**	**10.60**	**59.06**	**55.75**	**61.95**	**58.92**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	0.152	0.445	0.123	0.361	0.097	0.280
M'	0.186	0.545	0.150	0.442	0.119	0.343
$S \times M'$	0.263	0.772	0.213	0.625	0.169	0.486
W'	0.152	0.445	0.123	0.361	0.097	0.280
$S \times W'$	0.215	NS	0.174	NS	0.138	NS
$M' \times W'$	0.263	0.772	0.213	0.625	0.169	0.486
$S \times M' \times W'$	0.372	1.09	0.301	0.885	0.239	0.687
CV %	14.70		13.93		14.35	

4.2.4.2 The dry weight of weeds

The dry weight of weeds recorded at 60 DAS were statistically analysed and presented in table 4.23.

The dry weight of weeds did not vary much through the influence of levels of spacing during both the years as well as in pooled. However, the difference of dry weight of weeds infested in plots grown on close and broad spacings were found significant in 1995-96, 1996-97 and their pooled.

The data also showed that weed dry weight did not differ much due to variation in method of N application in either of the two years of experimentation as well as in pooled. However, the differences among them were found significant.

The results showed that dry weight of weeds increased steadily and significantly with the application of linuron over pendimethalin in both the years of experimentation and their pooled. The lower dry weight of weeds recorded (8.36 gm/sq. m) from the plots receiving pendimethalin in the form of Stomp 30 EC @ Kg.a.i/ha than that of the plots receiving linuron in the form of Afalon 50 WP @ 0.750 Kg.a.i/ha and the difference was also found significant. So, it proves that, crops receiving pendimethalin faced relatively less weed infestation than crops receiving linuron and accordingly recorded lower level of weed dry weight during both the years under study as well as in pooled (Fig. 4.20).

The interaction effects between levels of spacing and method of N application; method of N application and weed management; levels of spacing, method of N application and weed management though found significant on influencing the weed dry weights per sq.m but the interaction effect of levels of spacing and weed management was found not significant in both the years of experimentation and their pooled (Table 4.25).

4.2.5 Uptake of nutrients

The uptake of N, P and K were calculated on dry weight basis by multiplying the dry matter yield with their corresponding content of nutrient element and presented in table 4.25A.

Table 4.25A Effect of different management practices on uptake of nutrients in conserved residual moisture soil (Pooled data of two years)

Method of N application →		M'_1			M'_2			M'_3			Mean		
Spacing & weed management ↓		N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	W'_1	20.16	10.05	24.86	27.41	13.66	33.82	28.03	13.97	34.60	**25.20**	**12.56**	**31.11**
S_1	W'_2	23.67	11.80	29.22	39.08	19.48	48.21	24.52	12.22	30.24	**31.31**	**15.60**	**38.63**
	Mean	**21.92**	**10.90**	**27.04**	**33.25**	**16.57**	**41.01**	**29.61**	**14.75**	**36.53**	**28.26**	**14.07**	**34.85**
	W'_1	31.18	15.54	38.46	39.05	19.46	48.16	31.17	15.53	38.46	**33.80**	**16.84**	**41.71**
S_2	W'_2	39.05	19.46	48.16	42.77	21.32	52.77	39.08	19.47	48.21	**40.30**	**20.08**	**49.73**
	Mean	**28.52**	**14.21**	**35.18**	**37.08**	**18.48**	**45.74**	**32.37**	**16.13**	**39.94**	**32.65**	**16.26**	**40.27**
	W'_1	25.67	12.79	31.68	33.23	16.56	41.01	29.60	14.75	36.53	**29.50**	**14.70**	**36.41**
($S_1 + S_2$)	W'_2	31.36	15.63	38.17	40.85	20.38	50.47	35.13	17.51	43.36	**35.81**	**17.84**	**44.18**
	Mean	**28.52**	**14.21**	**35.20**	**37.08**	**18.48**	**45.74**	**32.37**	**16.13**	**39.94**	**32.65**	**16.26**	**40.27**

It was observed that uptake of N, P and K were associated with seed yield differences due to different treatment effects under different management practices. The potassium showed highest uptake followed by nitrogen. The phosphorus showed lesser uptake.

4.2.6 Economics of rainfed mustard production

Cost of cultivation, net return and return per rupee invested had been worked out, analysed and presented in table 4.26.

The results showed that crops receiving closer spacing reported significantly higher net return (Rs. 8038 ha^{-1}) than those of the crops receiving broader spacing due to high productivity through better utilization of residual moisture. Similar trend of results were also observed in case of return per rupee invested. Maximum return (1.72) per rupee invested was obtained from the crop grows on closer spacing. It was highly remunerative and was significantly higher than those obtained with the crop receiving broader spacing.

Method of N application also showed significant effect on influencing the economics of rainfed mustard production (Table 4.26). Net return from rainfed mustard increased significantly and steadily due to application of N in different methods. The highest net return (Rs. 8218 ha^{-1}) was obtained from the crop receiving 60 Kg ha^{-1} of N, supplied half as basal and remaining half through foliar sprays in three different splits (at 15, 30 and 45 DAS) and it was significantly superior to all other methods of N application under study (Fig. 4.21). Crop receiving lower N level (30 Kg ha^{-1}) supplied entirely through foliar sprays also paid very high net return (Rs. 7553 ha^{-1}) and which was significantly higher than those obtained with the application of 60 Kg/ha of N, supplied entirely as basal. the lowest net return (Rs. 5513 ha^{-1}) was recorded in crops receiving higher level of N (60 Kg/ha) supplied only as basal. The return per rupee invested also vary much due to the method of nitrogen management. Highest return (1.83) per rupee invested was obtained from the crop receiving higher level of N (60 Kg/ha) supplied half as basal and remaining half as foliar sprays at 15, 30 and 45 DAS. It was highly remunerative and was significantly higher than with the crop receiving higher level of N (60 Kg/ha) supplied entirely as basal and lower level of N (30 Kg/ha) supplied fully through foliar sprays (Fig. 4.22). The results clearly

Table 4.26 Effect of plant spacing, method of nitrogen application and weed management on economics of rainfed mustard cultivation (average over two years data)

Treatment	Cost of cultivation (Rs/ha)	Net return (Rs/ha)	Return per rupee invested
Spacing level			
S_1	4663	5210	1.11
S_2	4668	8038	1.72
S.Em (±)		271	0.31
C.D. at 5%		777	0.88
Method of N application			
M'_1	4463	5513	1.23
M'_2	4483	8218	1.83
M'_3	4183	7553	1.80
S.Em (±)		218	0.16
C.D. at 5%		625	0.45
Weed management			
W'_1	4201	6100	1.45
W'_2	4226	8049	1.90
S.Em (±)		228	0.18
C.D. at 5%		654	0.51
C.V. %		17.6	16.2

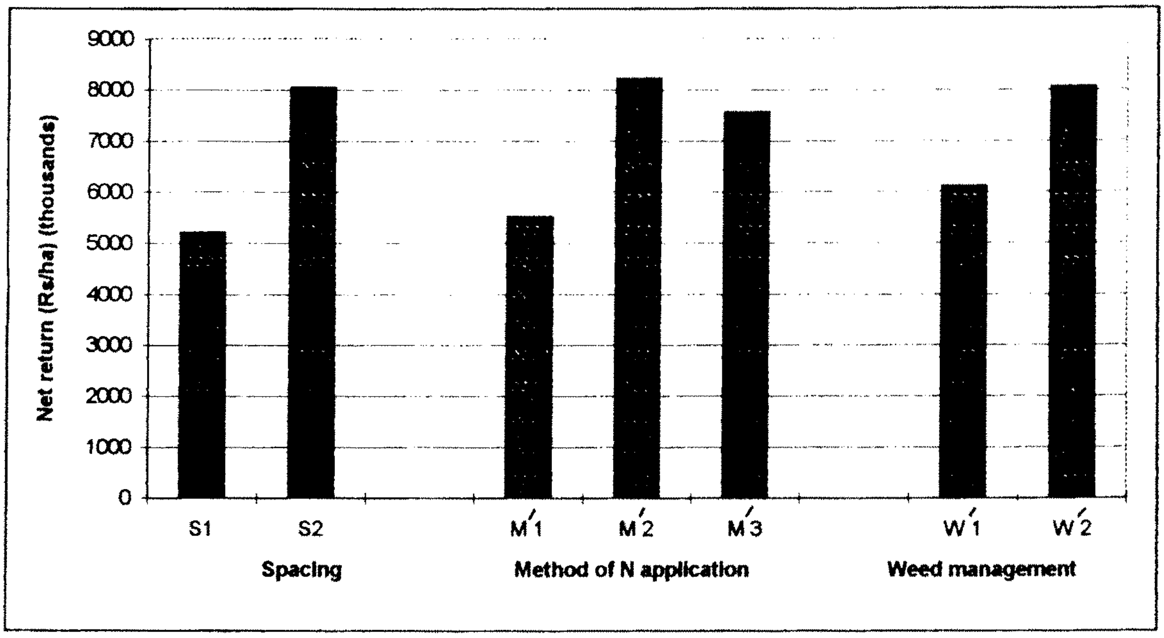

Fig. 4.21 Spacing, method of N application and weed management on net return of rainfed mustard

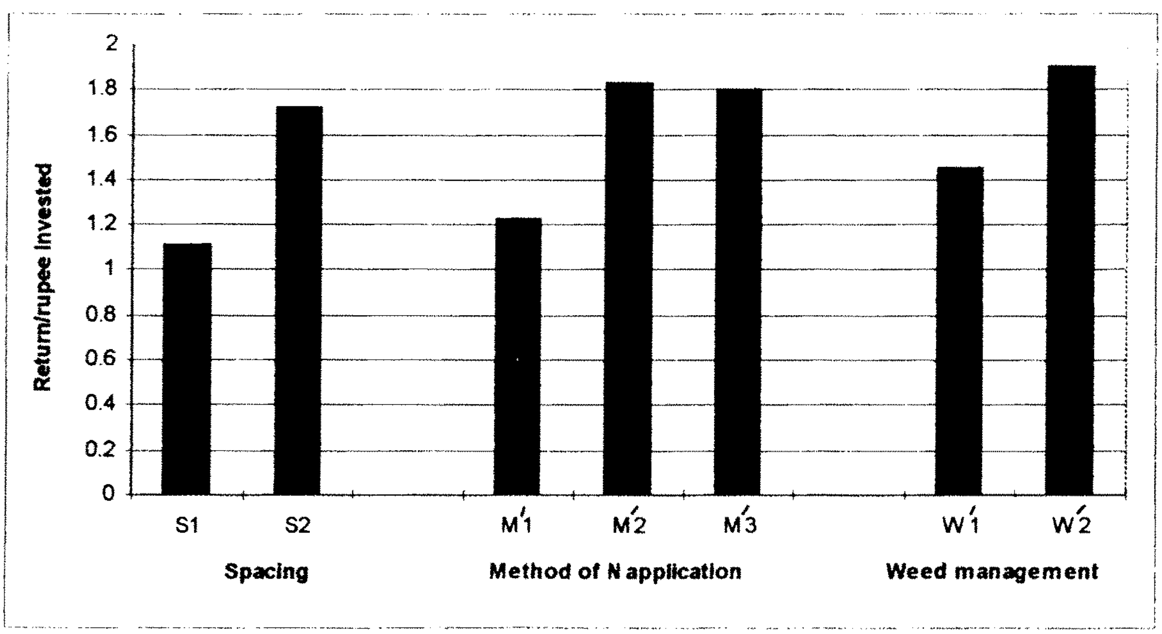

Fig. 4.22 Spacing, method of N application and weed management on return/rupee invested of rainfed mustard

showed the benefit of split application of nitrogenous fertilizer, half as basal and remaining half as foliar sprays for rainfed mustard cultivation under the new alluvial region of West Bengal.

The results also clearly indicated that crop receiving pendimethalin (Stomp 30 EC @ 1.0 Kg.a.i/ha) for weed management reported significantly higher net return (Rs. 8049 ha^{-1}) than those of the crop receiving linuron (Afalon 50 WP @ 0.750 Kg.a.i/ha) as weed managing treatment due to high productivity through better weed management. Similar trend of results were also observed in case of return per rupee invested. Maximum return (1.90) per rupee invested was obtained from the crop received pendimethalin for weed management as Stomp 30 EC @ 1.0 Kg.a.i/ha. It was very highly remunerative and was significantly higher than those obtained with the crop received linuron as Afalon 50 WP @ 0.750 Kg.a.i/ha for weed management.

CHAPTER V

DISCUSSION

Though there has been a significant improvement in the performance of India's vegetable oil sector in the last one decade, the benefits of Green Revolution got neutralised due to the ever increasing human population, fertilizer shortage, limited resources of irrigation and the increasing cost of inputs of crop production specially fertilizer and irrigation, in particular. Therefore, a high level sustainable production should be the strategy in production technology of oilseeds including mustard.

Agronomists' approach in two ways to bring a high level sustainable production of mustard crop. The first is to apply modern scientific know how with all input of crop production. This is usually done through the application of balanced dose of fertilizer with sound crop management practices. The second approach is to increase the yield levels through adoption of viable and well founded technologies relevant to Indian farmer and environment followed by exploring the feasibility of increasing yield levels by employing our best available technology with utmost crop management practices. This is possible by the use of high yielding deep rooted mustard cultivar with well adopted climatic condition characteristics which can successfully extract moisture from deeper zone of soil profile. The residual moisture conservation with sound fertilizer and crop management practices such as close plant spacing, weed control and foliar spray application of nitrogenous fertilizer are also important factors.

In India Mustard seed production under adequate supply of fertilizer, irrigation and all input, it has been a standard practice to apply nitrogenous fertilizer in soil in two or three splits depending upon the fertility and texture of the soil and duration of the mustard cultivar. Nominal use or no use of fertilizer is a rule where hostile condition of crop growth is prevalent specially on dry and marginal lands, in particular. In recent years, research to achieve increased production and productivity of mustard has centered in two major fields. One is through area expansion through with limited scope, bringing larger area under irrigation over a longer period followed by proper fertilizer and water management practices. The other inputs of crop management such as high yielding variety, optimum plant density and weed control are also important factors. A second is through conservation of residual soil moisture, suitable crop geometry, weed control and proper fertilizer and crop management practices. The choice of a high yielding mustard cultivar well adopted to local condition of the region such as short winter and rainfall pattern are also very critical; boosting production of mustard crop grown under moisture stress condition with all input and technical know how including close plant spacing and foliar application of nitrogen fall in this category.

5.1 Effect of management practices

5.1.1 Productivity

5.1.1.1 Seed yield

From the summary of results presented in Table 5.1 it is apparent that use of irrigation water as water management practice showed higher increased mustard seed productivity as compared to water management by conserved residual soil moisture. Similar trend was visualised in case of weed management by herbicide and crop geometry practice under different crop management practices (table 5.3 and 5.4). The beneficial effect of irrigation was also reported by many workers (Krogman and Hobbes, 1975; Parihar *et al.,* 1981; Khan and Agrawal, 1985; Singh and Srivastava, 1986; Samui *et al.,* 1986; Prasad and Eshanullah, 1988; Singh *et. al.,* 1989 and Prakash *et. al.,* 1992).

Fertilizer management practice in irrigated soil with 80 kg N/ha applied half as basal and half as top dress showed highest seed yield followed by 60 kg N/ha applied half as basal and half as foliar spray in conserved residual moisture soil. Foliar spray of nitrogen in irrigated soil and conserved residual moisture soil did not show any appreciable yield differences among themselves. Basal application of nitrogen both in irrigated soil and conserved residual moisture soil yielded the lowest and the differences among themselves were negligible (Table 5.2). The higher seed yield due to application of nitrogen through split doses was pointed out by Lahiri and De (1971); Mandal and Gaffer (1983), Gaffer and Rajjaque (1984) and Berti and Mosca (1987).

For any agronomic practice to be easily accepted by the farmers the yield differences between different management practices such as water and fertilizer should

Table 5.1 Summary of the results showing the effect of water management on seed yield of mustard (Pooled data of two years)

Particulars	Seed yield (Kg/ha)
Water management by irrigation	1049.80
Water management by conservation of residual soil moisture	980.75

Table 5.2 Summary of the results showing the effect of fertilizer management on seed yield of mustard (Pooled data of two years)

Particulars	Seed yield (Kg/ha)
Fertilizer management in irrigated soil :	
i) 80 Kg N/ha as basal application	850.25
ii) 80 Kg N/ha applied half as basal and the remaining half as top dressing before first irrigation (30-35 DAS)	1342.20
iii) 40 Kg N/ha as foliar spray at 15, 30, 45 and 60 DAS @ 5, 10, 15 and 10 Kg N/ha respectively through 2% urea solution	954.79
Fertilizer management in conserved residual moisture soil :	
i) 60 Kg N/ha as basal application	856.50
ii) 60 Kg N/ha applied half as basal and the remaining half as foliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 Kg N/ha respectively through 2% urea solution	1113.62
iii) 30 Kg N/ha as foliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 Kg N/ha respectively through 2% urea solution	972.12

Table 5.3 Summary of the results showing the effect of weed management on seed yield of mustard (Pooled data of two years)

Particulars	Seed yield (Kg/ha)
Weed management in irrigated soil	1049.08
Weed management in conserved residual moisture soil	980.75

Table 5.4 Summary of the results showing the effect of crop geometry on seed yield of mustard (Pooled data of two years)

Particulars	Seed yield (Kg/ha)
With optimum plant spacing in irrigated soil	1049.08
With optimum plant spacing in conserved residual moisture soil	848.69
With close plant spacing in conserved residual moisture soil	980.75

Table 5.5 Summary of the results showing the effect of different managment practices on the percentage increase of mustard seed yield (Pooled data of two years)

Particulars	Water management	Fertilizer management	Weed management	Crop geometry practices
	% increase over conserved residual moisture soil	% increase over soil application of N fertilizer in conserved residual moisture soil	% increase over use of Afalon (linuron) 50 WP @ 0.750Kg a.i./ha in conserved residual moisture soil	% increase over optimum plant spacing in conserved residual moisture soil
Water management : i) with one irrigation	-11.09			
ii) with two irrigation	23.92			
Fertilizer management in irrigated soil :				
i) 80 kg N/ha as basal application		-0.73		
ii) 80 kg N/ha applied half as basal and the remaining half as top dressing before first irrigation (30 - 35 DAS)		56.70		
iii) 40 kg N/ha as foliar spray at 15, 30, 45 and 60 DAS @ 5, 10, 15 and 10 kg N/ha respectively through 2% urea solution		11.47		
Fertilizer management in conserved residual moisture soil :				
i) 60 kg N/ha applied half as basal and the remaining half as foliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 kg N/ha respectively through 2% urea solution		30.01		
ii) 30 kg N/ha as foliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 kg N/ha respectively through 2% urea solution		13.49		
Weed management :				
i) Use of Afalon (linuron) 50 WP @ 0.750 kg a.i./ha in irrigated soil			-5.26	
ii) Use of Stomp (pendimethalin) 30 EC @ 1.0 kg a.i./ha in irrigated soil			41.78	
iii) Use of Stomp (pendimethalin) 30 EC @ 10 kg a.i./ha in conserved residual moisture soil			18.39	
Crop geometry practices :				
i) With optimum plant spacing in irrigated soil				23.69
ii) With close plant spacing in conserved residual moisture soil				15.56

be of higher order and at least be of the order of 20 per cent. The other important management practices such as weed management and crop geometry practice, the yield differences should at least be of the order of 15 per cent. From table 5.5, 4.9 and 4.23 it is apparent that mustard crop receiving irrigation under water management practice, increased the seed yield to the extent of 23.92 per cent in comparison to seed yield obtained in conserved residual moisture soil; application of one irrigation showed a negative increase of 11.09 per cent.

Fertilizer management practice followed in irrigated soil with 80 kg N/ha applied half as basal and half as top dressing increased the seed yield to the tune of 56 per cent in comparison to 60 kg N/ha applied as basal in conserved residual moisture soil followed by 60 kg N/ha applied half as basal and half as foliar spray in conserved residual moisture soil with 30.01 per cent increased seed yield. Foliar application of nitrogen in irrigated soil and conserved residual moisture soil showed only 11.47 and 13.49 per cent increased seed yield respectively (Table 5.5., 4.9 and 4.23).

The management of weeds by suppressive effect of herbicide linuron and pendimethalin showed that pendimethalin in irrigated soil increased the seed yield to the extent of 41.78 per cent in comparison to linuron in conserved residual moisture soil. Pendimethalin in conserved residual moisture soil showed only 18.39 per cent increased seed yield (Table 5.5, 4.9 and 4.23). It is also apparent that herbicide linuron is less beneficial specially in irrigated soil (-5.26 per cent increased seed yield) (table 5.5, 4.9 and 4.23). This may be due to increased toxicity of herbicide linuron under irrigated condition as water solution of linuron penetrates deep in root zone of crop and thus affecting the crop growth. The better management of weeds by using herbicides pendimethalin was reported by many workers (Adamczewski *et al.*, 1987; Mohamed, 1988; Dixon *et al.*, 1989 and Dubey *et al.*, 1988).

The crop geometry followed by adopting the normal optimum plant spacing in irrigated soil showed 23.69 per cent increased seed yield in comparison to normal optimum plant spacing in conserved residual moisture soil. Close plant spacing in conserved residual moisture soil increased the seed yield to the tune of 15.56 per cent (Table 5.5, 4.9 and 4.23). The beneficial effect of plant spacing including close plant spacing in conserved residual moisture soil had been highlighted by many workers (

Table 5.6 Summary of the results showing the effect of water management on economic yield (Rs/ha) of mustard (Pooled data of two years)

Particulars	Economic yield (Rs/ha)
Water management by irrigation water	12086.50
Water management by conserved residual soil moisture	11289.50

Table 5.7 Summary of the results showing the effect of fertilizer management on economic yield (Rs/ha) of mustard (Pooled data of two years)

Particulars	Economic yield (Rs/ha)
Fertilizer management in irrigated soil :	
i) 80 Kg N/ha as basal application	9910
ii) 80 Kg N/ha applied half as basal and the remaining half as top dressing before first irrigation (30-35 DAS)	15289
iii) 40 Kg N/ha as foliar spray at 15, 30, 45 and 60 DAS @ 5, 10, 15 and 10 Kg N/ha respectively through 2% urea solution	11064
Fertilizer management in conserved residual moisture soil :	
i) 60 Kg N/ha as basal application	9976
ii) 60 Kg N/ha applied half as basal and the remaining half as foliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 Kg N/ha respectively through 2% urea solution	12701
iii) 30 Kg N/ha as foliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 Kg N/ha respectively through 2% urea solution	11736

Table 5.8 Summary of the results showing the effect of weed management on economic yield (Rs/ha) of mustard (Pooled data of two years)

Particulars	Economic yield (Rs/ha)
Weed management in irrigated soil	120868.50
Weed management in conserved residual moisture soil	11288.00

Table 5.9 Summary of the results showing the effect of crop geometry on economic yield (Rs/ha) of mustard (Pooled data of two years)

Particulars	Economic yield (Rs/ha)
With optimum plant spacing in irrigated soil	12086.50
With optimum plant spacing in conserved residual moisture soil	9873.00
With close plant spacing in conserved residual moisture soil	12706.00

Patel *et. al.,* 1980; Shaik Khader and Bhargava 1985; Singh and Singh 1987 and Gupta 1988).

5.1.1.2 Effect on Stover Yield

The stover yield differences were similar to seed yield differences due to different treatment differences under different management practices (Appendix table 1.11 and 2.11).

5.1.1.3 Effect on Harvest Index

The trend of harvest index value was similar to seed and stover yield differences due to the effect of different treatment differences under different management practices (appendix table 1.12 and 2.12).

5.1.1.4 Effect on Oil Content

The oil content of mustard seed was not affected due to different treatment differences under different management practices (Appendix table 1.13 and 2.13). This may be due to the plant nutrients which affect oil content were not a limiting factor in these experiments under study.

5.1.1.5 Effect on Weed infestation

Weed infestation was not affected by different crop management practices except herbicide and close plant spacing which helped controlling weed infestation. Weed infestation was controlled satisfactorily by the use of herbicide pendimethalin and increased the seed yield in comparison to herbicide linuron. The herbicide linuron was less beneficial in irrigated soil which may be due to its increased toxicity effect on root zone of mustard crop by the solution of herbicide linuron with irrigation water (table 4.11 and 4.25).

5.1.2 Effect on yield components

The treatment effect of different management practices which increased yields also showed evidence that this was possible through the increase in number of branches, number of siliqua per plant and number of seeds per siliquae (appendix tables 1.1, 1.2, 1.9, 1.10, 2.1, 2.2, 2.9 and 2.10). As presented in details in chapter of results the treatment effect of different management practices was not appreciable on

Table 5.10 Summary of the results showing the effect of different managment practices on the percentage increase of economic yield of mustard (Pooled data of two years)

Particulars	Water management	Fertilizer management	Weed management	Crop geometry practices
	% increase over conserved residual moisture soil	% increase over soil application of N fertilizer in conserved residual moisture soil	% increase over use of Afalon (linuron) 50 WP @ 0.750Kg a.i./ha in conserved residual moisture soil	% increase over optimum plant spacing in conserved residual moisture soil
Water management : i) with one irrigation	-9.86			
ii) with two irrigation	23.09			
Fertilizer management in irrigated soil :				
i) 80 kg N/ha as basal application		-0.60		
ii) 80 kg N/ha applied half as basal and the remaining half as top dressing before first irrigation (30 - 35 DAS)		53.21		
iii) 40 kg N/ha as foliar spray at 15, 30, 45 and 60 DAS @ 5, 10, 15 and 10 kg N/ha respectively through 2% urea solution		10.90		
Fertilizer management in conserved residual moisture soil :				
i) 60 kg N/ha applied half as basal and the remaining half as foliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 kg N/ha respectively through 2% urea solution		27.31		
ii) 30 kg N/ha as foliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 kg N/ha respectively through 2% urea solution		17.64		
Weed management :				
i) Use of Afalon (linuron) 50 WP @ 0.750 kg a.i./ha in irrigated soil			-4.77	
ii) Use of Stomp (pendimethalin) 30 EC @ 1.0 kg a.i./ha in irrigated soil			39.21	
iii) Use of Stomp (pendimethalin) 30 EC @ 10 kg a.i./ha in conserved residual moisture soil			19.16	
Crop geometry practices :				
i) With optimum plant spacing in irrigated soil				22.41
ii) With close plant spacing in conserved residual moisture soil				28.69

Table 5.11 Summary of the results showing the effect of different managment practices on of economic yield of mustard per rupee invested (Pooled data of two years)

Particulars	Water management	Fertilizer management	Weed management	Crop geometry practices
Water management : i) In irrigated soil	1.29			
ii) In conserved residual moisture soil	1.41			
Fertilizer management in irrigated soil :				
i) 80 kg N/ha as basal application		0.99		
ii) 80 kg N/ha applied half as basal and the remaining half as top dressing before first irrigation (30 - 35 DAS)		1.90		
iii) 40 kg N/ha as foliar spray at 15, 30, 45 and 60 DAS @ 5, 10, 15 and 10 kg N/ha respectively through 2% urea solution		1.29		
Fertilizer management in conserved residual moisture soil :		1.23		
iv) 60 kg N/ha applied as basal				
v) 60 kg N/ha applied half as basal and the remaining half asfoliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 kg N/ha respectively through 2% urea solution		1.85		
vi) 30 kg N/ha as foliar spray at 15, 30 and 45 DAS @ 5, 15 and 10 kg N/ha respectively through 2% urea solution		1.80		
Weed management :				
i) Use of Afalon (linuron) 50 WP @ 0.750 kg a.i./ha in irrigated soil			1.13	
ii) Use of Stomp (pendimethalin) 30 EC @ 1.0 kg a.i./ha in irrigated soil			2.10	
iii) Use of Afalon (linuron) 50 WP @ 0.750 kg a.i./ha in conserved residual moisture soil			1.45	
iv) Use of Stomp (pendimethalin) 30 EC @ 10 kg a.i./ha in conserved residual moisture soil			1.90	
Crop geometry practices :				
i) With optimum plant spacing in irrigated soil				1.29
ii) With optimum plant spacing in conserved residual moisture soil				1.11
iii) With close plant spacing conserved residual moisture soil				1.72

height and test weight (1000-seed weight) of mustard seed. (table 4.2, 4.16, 4.7 an 4.21).

5.1.3 Effect on growth attributes

As presented in details in chapter of results the leaf area indices, crop growth rate and net assimilation rate at different stages of growth showed similar trend as seed yield differences due to different treatment effects under different management practice (Table 4.3, 4.4, 4.5, 4.6, 4.7, 4.8, 4.19 and 4.20).

5.1.4 Effect on uptake of nutrients

The uptake pattern of N, P and K due to the effect of different management practices was similar to treatment differences of mustard yield due to effect of different management practice (table 5.12 and 5.13).

5.1.5 Effect on Economic Yield in term of rupees per hectare

The trend was similar to seed yield differences due to the effect of different treatments under different management practices except the crop management practices with close plant spacing in conserved residual moisture soil with high per cent increase (28.69%) of Economic Yield in terms of rupees per hectare. (Table 5.6, 5.7, 5.8, 5.9, 5.10, 4.14 and 4.28). The economic yield of mustard per rupee invested (table 5.11) was fairly high in all crop management practice when the mustard crop was raised in conserved residual moisture soil (table 5.6, 4.14 and 4.28) except the fertilizer management practices with split dose of nitrogen and weed management practices with herbicide pendimethalin in irrigated soil; however, the differences were not much (table 5.8).

CHAPTER VI

SUMMARY AND CONCLUSION

In order to analyse the growth and evaluate the productivity and economics of mustard production under different management practices, two field experiments were conducted in sandy clay loam soil with high percolation rate for two consecutive short duration mild winter seasons. The following results were obtained with different treatments and under different management practices.

Water management with irrigation water showed higher mustard seed yield in comparison to mustard seed produced in conserved residual moisture soil. The weed management with herbicide and crop management by adopting proper plant spacing showed similar trend.

The fertilizer management with 80 kg N/ha applied half as basal and half as top dressing, yielded the highest seed yield in irrigated soil followed by application of 60 kg N/ha applied half as basal and half as foliar spray in conserved residual moisture soil. The foliar spray of nitrogen alone did not show any encouraging results. The basal application of nitrogen yielded the lowest seed yield.

Water management with two irrigation increased the seed yield to the tune of 23.92 per cent in comparison to mustard seed yield in conserved residual moisture soil; one irrigation showed a negative increase of 11.09 per cent.

The fertilizer management in irrigated soil with split application of nitrogen (80Kg N/ha)applied half as basal and half as top dressing increased the seed yield to the extent of 56 per cent in comparison to basal application of nitrogen (60 Kg N/ha) in conserved residual moisture soil. The split application of nitrogen (60 Kg N/ha) applied half as basal and half as foliar spray in conserved residual moisture soil showed 30.01 per cent increased seed yield. The per cent increased seed yield with foliar spray alone was not high (11.47 to 13.49 per cent).

Weed management by use of herbicide in irrigated soil showed that pendimethalin increased the seed yield to the tune of 41.78 per cent in comparison to linuron in conserved residual moisture soil. Pendimethalin in conserved residual moisture soil resulted 18.39 per cent increased seed yield. The herbicide linuron was less beneficial in irrigated soil.

The crop management practice with proper plant spacing in irrigated soil showed 23.69 per cent increased seed yield in comparison to normal optimum plant spacing in conserved residual moisture soil. The close plant spacing in conserved residual moisture soil recorded 15.56 per cent increased seed yield.

The stover yield and harvest index value showed similar trend as seed yield differences due to different treatment differences and under different management practices.

The oil content of mustard seed was not affected by treatment differences under different management practices.

Weed infestation was affected by herbicide and close plant spacing. The herbicide pendimethalin was more beneficial than linuron.

The yield increases in mustard were mainly due to the increase in the number of branches, number of siliqua per plant and number of seeds per siliquae.

The different treatments under different management practices which gave higher seed yield, also increased leaf area indices, crop growth rate and net assimilation rate.

The uptake of N, P and K were associated with seed yield differences due to different treatments under different management practices.

The economic yield in terms of rupees per hectare showed similar trend as seed yield except the crop management practice in conserved residual moisture soil with closer plant spacing which exhibited highest percentage increase in seed yield (28.69%). The economic yield per rupee invested was fairly high in conserved residual moisture soil under different management practices except the fertilizer management with split dose of nitrogen and weed management with pendimethalin in irrigated soil; however, the differences were not appreciable.

Thus it may be concluded that with adequate water supply, the crop management practices with two irrigation, 80Kg N/ha in splits, use of herbicide pendimethalin and adopting proper crop geometry, the resourceful farmers may achieve maximum mustard seed yield and economic return. When water is scarce, it is possible to raise mustard crop with substantial high yield (1284Kg/ha) in conserved residual moisture soil with 60Kg N/ha applied in splits including foliar spray, replacing the practice of top dressing, use of herbicide pendimethalin and crop management practice of close plant spacing; the farmers with limited resources may follow this type of crop management to achieve high economic return per rupee invested.

CHAPTER VII

FUTURE SCOPE OF RESEARCH

The continuous increase of human population and thereby increasing needof more mustard seed production demands further improvement in mustard production and future work may be centered around on these lines :

1. Adoption of improved short duration mustard cultivar with very high yield potentiality.

2. Use of split dose of nitrogen including foliar spray in place of top dressing in irrigated soil.

3. Proper utilisation of irrigation water *i.e.* more irrigation efficiency.

4. Improvement in conservation of more residual soil moisture.

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APPENDIX TABLES

Table 1.1 Interaction effects between irrigation, method of N application and weed management on no. of primary branches per plant

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	4.08	5.40	5.08	**4.85**	4.20	5.13	4.93	**4.75**	4.14	5.26	5.00	**4.80**
	W_2	4.83	7.10	5.60	**5.85**	4.89	7.52	5.47	**5.96**	4.86	7.31	5.55	**5.91**
	Mean	**4.46**	**6.25**	**5.35**	**5.35**	**4.54**	**6.32**	**5.20**	**5.35**	**4.50**	**6.29**	**5.27**	**5.35**
I_2	W_1	5.67	6.50	5.61	**5.92**	5.77	6.91	6.36	**6.35**	5.72	6.71	5.98	**6.13**
	W_2	7.63	8.45	6.46	**7.51**	7.36	8.82	6.47	**7.71**	7.49	8.63	6.71	**7.61**
	Mean	**6.50**	**7.47**	**6.03**	**6.72**	**6.57**	**7.86**	**6.66**	**7.03**	**6.61**	**7.67**	**6.35**	**6.87**
($I_1 + I_2$)	W_1	4.87	5.95	5.34	**5.39**	4.98	6.02	5.64	**5.55**	4.93	5.98	5.49	**5.47**
	W_2	6.23	7.77	6.04	**6.68**	6.12	8.17	6.22	**6.84**	6.18	7.97	6.13	**6.76**
	Mean	**5.55**	**6.86**	**5.69**	**6.03**	**5.55**	**7.09**	**5.93**	**6.19**	**5.55**	**6.98**	**5.81**	**6.11**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.086	0.254	0.062	0.183	0.053	0.153
M	0.106	0.311	0.076	0.225	0.065	0.188
I x M	0.150	0.442	0.108	0.318	0.092	0.265
W	0.086	0.254	0.062	0.183	0.053	0.153
I x W	0.122	0.359	0.088	NS	0.075	0.217
M x W	0.150	0.442	0.108	0.318	0.092	0.265
I x M x W	0.212	NS	0.153	0.450	0.131	0.376
CV %	12.09		11.29		13.25	

Table 1.2 Interaction effects between irrigation, method of N application and weed management on no. of secondary branches per plant

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	5.24	6.61	8.14	**6.66**	5.88	6.64	6.40	**6.30**	5.56	6.62	7.27	**6.48**
	W_2	5.94	8.10	6.99	**7.01**	6.10	9.06	7.09	**7.41**	6.02	7.27	7.04	**7.21**
	Mean	**5.59**	**7.35**	**7.57**	**6.84**	**5.99**	**7.85**	**6.75**	**6.86**	**5.79**	**7.04**	**7.16**	**6.85**
I_2	W_1	6.92	7.80	7.05	**7.25**	7.47	8.06	7.76	**7.76**	7.19	7.93	7.40	**7.51**
	W_2	9.10	10.04	7.86	**9.00**	8.91	10.55	8.35	**9.29**	9.04	10.30	8.10	**9.51**
	Mean	**8.01**	**8.92**	**7.45**	**8.13**	**8.22**	**9.30**	**8.09**	**8.53**	**8.12**	**9.11**	**7.75**	**8.33**
($I_1 + I_2$)	W_1	6.08	7.20	7.60	**6.96**	6.67	7.35	7.08	**7.03**	6.37	7.27	7.34	**7.00**
	W_2	7.52	9.07	7.43	**8.01**	7.54	9.80	7.72	**8.35**	7.53	9.44	7.57	**8.18**
	Mean	**6.80**	**8.14**	**7.51**	**7.48**	**7.10**	**8.57**	**7.40**	**7.69**	**6.95**	**8.93**	**7.44**	**7.59**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.066	0.193	0.072	0.211	0.048	0.140
M	0.081	0.237	0.088	0.258	0.059	0.171
I x M	0.114	0.335	0.124	0.365	0.084	0.242
W	0.066	0.193	0.072	0.211	0.048	0.140
I x W	0.093	0.274	0.101	NS	0.069	0.198
M x W	0.114	0.335	0.124	0.365	0.084	0.242
I x M x W	0.161	0.474	0.176	0.517	0.119	0.343
CV %	13.75		12.97		12.86	

Table 1.3 Interaction effects between irrigation, method of N application and weed management on leaf area index at 20 DAS

Method of N application → / Irrigation & weed management ↓		1995-96				1996-97				Pooled			
		M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	0.198	0.219	0.215	**0.211**	0.194	0.232	0.222	**0.215**	0.195	0.225	0.219	**0.213**
	W_2	0.212	0.264	0.216	**0.232**	0.214	0.302	0.242	**0.253**	0.213	0.285	0.229	**0.244**
	Mean	**0.205**	**0.244**	**0.216**	**0.222**	**0.203**	**0.267**	**0.232**	**0.234**	**0.204**	**0.255**	**0.224**	**0.268**
I_2	W_1	0.224	0.248	0.230	**0.234**	0.255	0.278	0.240	**0.285**	0.240	0.263	0.235	**0.246**
	W_2	0.285	0.365	0.288	**0.313**	0.298	0.370	0.290	**0.319**	0.290	0.368	0.289	**0.316**
	Mean	**0.255**	**0.307**	**0.259**	**0.273**	**0.277**	**0.324**	**0.260**	**0.289**	**0.266**	**0.315**	**0.262**	**0.281**
($I_1 + I_2$)	W_1	0.211	0.233	0.223	**0.222**	0.224	0.255	0.231	**0.236**	0.217	0.244	0.227	**0.229**
	W_2	0.249	0.317	0.252	**0.273**	0.256	0.336	0.266	**0.286**	0.252	0.326	0.259	**0.279**
	Mean	**0.230**	**0.275**	**0.237**	**0.47**	**0.240**	**0.295**	**0.248**	**0.261**	**0.235**	**0.285**	**0.243**	**0.254**

	1995-96 SEm (±)	1995-96 CD (P=0.05)	1996-97 SEm (±)	1996-97 CD (P=0.05)	Pooled SEm (±)	Pooled CD (P=0.05)
I	0.003	0.010	0.002	0.007	0.002	0.006
M	0.004	0.012	0.002	0.008	0.002	0.007
I x M	0.006	NS	0.004	0.012	0.003	0.010
W	0.003	0.010	0.002	0.007	0.002	0.006
I x W	0.005	0.014	0.003	0.009	0.003	0.008
M x W	0.006	0.019	0.004	0.012	0.003	0.010
I x M x W	0.008	NS	0.005	NS	0.005	NS
CV %	12.12		13.84		14.05	

Table 1.4 Interaction effects between irrigation, method of N application and weed management on leaf area index at 40 DAS of rainfed mustard

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	1.09	1.30	1.32	**1.23**	1.10	1.32	1.21	**1.21**	1.09	1.31	1.26	**1.22**
	W_2	1.20	1.80	1.12	**1.37**	1.22	1.90	1.25	**1.45**	1.21	1.85	1.18	**1.41**
	Mean	**1.14**	**1.55**	**1.22**	**1.30**	**1.16**	**1.61**	**1.23**	**1.33**	**1.15**	**1.58**	**1.22**	**1.31**
I_2	W_1	1.30	1.32	1.28	**1.30**	1.28	1.50	1.42	**1.40**	1.29	1.41	1.35	**1.35**
	W_2	1.68	1.90	1.36	**1.64**	1.44	1.98	1.50	**1.64**	1.56	1.94	1.43	**1.69**
	Mean	**1.49**	**1.61**	**1.32**	**1.47**	**1.36**	**1.74**	**1.46**	**1.52**	**1.42**	**1.67**	**1.39**	**1.49**
($I_1 + I_2$)	W_1	1.19	1.31	1.30	**1.26**	1.19	1.41	1.31	**1.30**	1.19	1.36	1.30	**1.28**
	W_2	1.44	1.85	1.24	**1.51**	1.33	1.94	1.37	**1.54**	1.38	1.89	1.30	**1.52**
	Mean	**1.31**	**1.58**	**1.27**	**1.38**	**1.26**	**1.67**	**1.34**	**1.42**	**1.28**	**1.62**	**1.30**	**1.40**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.018	0.052	0.011	0.033	0.010	0.030
M	0.022	0.064	0.013	0.040	0.013	0.037
I x M	0.031	0.091	0.19	0.057	0.018	0.052
W	0.18	0.058	0.011	0.033	0.010	0.030
I x W	0.025	0.074	0.015	NS	0.015	0.043
M x W	0.031	0.091	0.019	0.057	0.018	0.052
I x M x W	0.044	NS	0.027	NS	0.026	NS
CV %	13.49		13.35		14.52	

Table 1.5 Interaction effects between irrigation, method of N application and weed management on leaf area index at 60 DAS

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	4.11	5.11	5.25	**4.82**	4.08	5.20	5.42	**4.90**	4.09	5.15	5.33	**4.86**
	W_2	4.44	5.93	4.88	**5.08**	4.52	6.08	4.98	**5.19**	4.48	6.00	4.93	**5.13**
	Mean	**4.27**	**5.52**	**5.06**	**4.95**	**4.30**	**5.64**	**5.20**	**5.04**	**4.28**	**5.58**	**5.13**	**5.00**
I_2	W_1	5.22	5.44	5.15	**5.27**	5.48	5.66	5.32	**5.48**	5.35	5.55	5.23	**5.37**
	W_2	5.73	6.25	5.32	**5.76**	5.62	6.32	5.42	**5.78**	5.67	6.28	5.37	**5.77**
	Mean	**5.47**	**5.84**	**5.23**	**5.51**	**5.55**	**5.99**	**5.37**	**5.63**	**5.51**	**5.91**	**5.30**	**5.57**
$(I_1 + I_2)$	W_1	4.66	5.27	5.20	**5.04**	4.78	5.43	5.37	**5.19**	4.72	5.35	5.28	**5.12**
	W_2	5.08	6.09	5.10	**5.42**	5.07	6.20	5.20	**5.49**	5.07	6.14	5.15	**5.45**
	Mean	**4.87**	**5.68**	**5.15**	**5.23**	**4.92**	**5.81**	**5.28**	**5.34**	**4.90**	**5.74**	**5.21**	**5.28**

	1995-96 SEm (±)	1995-96 CD (P=0.05)	1996-97 SEm (±)	1996-97 CD (P=0.05)	Pooled SEm (±)	Pooled CD (P=0.05)
I	0.022	0.065	0.016	0.046	0.013	0.039
M	0.027	0.080	0.019	0.057	0.016	0.048
I x M	0.038	0.133	0.027	0.081	0.023	0.068
W	0.022	0.065	0.016	0.046	0.013	0.039
I x W	0.031	0.092	0.022	NS	0.019	0.055
M x W	0.038	0.0153	0.027	0.081	0.023	0.068
I x M x W	0.054	0.161	0.039	0.114	0.033	0.096
CV %	11.81		11.27		11.56	

Table 1.6 Interaction effects between irrigation, method of N application and weed management on leaf area index at 80 DAS

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
	W_1	2.24	2.72	2.65	**2.53**	2.32	2.77	2.76	**2.61**	2.28	2.74	2.70	**2.57**
I_1	W_2	2.28	3.10	2.32	**2.56**	2.42	2.94	2.48	**2.61**	2.35	3.02	2.40	**2.59**
	Mean	**2.26**	**2.91**	**2.48**	**2.55**	**2.37**	**2.85**	**2.62**	**2.61**	**2.31**	**2.88**	**2.55**	**2.58**
	W_1	2.78	2.52	2.73	**2.67**	2.92	2.67	2.93	**2.84**	2.85	2.59	2.83	**2.75**
I_2	W_2	2.69	3.50	2.86	**3.01**	2.85	3.68	2.88	**3.13**	2.77	3.59	2.87	**3.07**
	Mean	**2.73**	**3.01**	**2.79**	**2.84**	**2.88**	**3.17**	**2.90**	**2.91**	**2.81**	**3.09**	**2.85**	**2.91**
	W_1	2.51	2.62	2.69	**2.60**	2.62	2.72	2.84	**2.72**	2.56	2.67	2.76	**2.66**
$(I_1 + I_2)$	W_2	2.48	3.30	2.59	**2.79**	2.63	3.31	2.68	**2.87**	2.56	3.30	2.63	**2.83**
	Mean	**2.49**	**2.96**	**2.64**	**2.69**	**2.62**	**3.01**	**2.75**	**2.80**	**2.56**	**2.96**	**2.70**	**2.75**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.014	0.041	0.040	0.119	0.021	0.062
M	0.017	0.051	0.049	0.146	0.026	0.075
I x M	0.024	0.072	0.070	NS	0.037	0.107
W	0.014	0.041	0.040	0.119	0.021	0.062
I x W	0.020	0.058	0.057	0.168	0.030	0.087
M x W	0.024	0.072	0.070	0.207	0.037	0.107
I x M x W	0.034	0.101	0.099	0.292	0.052	0.151
CV %	12.23		12.17		14.71	

Table 1.7 Interaction effects between irrigation, method of N application and weed management on crop growth rate at 20 - 40 DAS

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	8.97	9.07	8.94	**8.99**	9.02	9.15	9.22	**9.13**	8.99	9.11	9.08	**9.06**
	W_2	9.04	12.67	9.12	**10.27**	9.12	12.55	9.35	**10.34**	9.08	12.61	9.23	**10.30**
	Mean	**9.00**	**10.87**	**9.03**	**9.63**	**9.07**	**10.85**	**9.28**	**9.73**	**9.03**	**10.86**	**9.15**	**9.68**
I_2	W_1	9.32	10.00	9.42	**9.58**	9.32	10.20	9.72	**9.74**	9.32	10.10	9.57	**9.66**
	W_2	11.67	13.75	10.15	**11.85**	10.98	13.58	10.19	**11.58**	11.32	13.66	10.17	**7.72**
	Mean	**10.49**	**11.87**	**9.78**	**10.71**	**10.15**	**11.89**	**9.95**	**10.66**	**10.32**	**11.88**	**9.87**	**10.69**
($I_1 + I_2$)	W_1	9.14	9.53	9.18	**9.28**	9.17	9.67	9.47	**9.43**	9.15	9.60	9.32	**9.36**
	W_2	10.35	13.21	98.63	**11.06**	10.05	13.06	9.77	**10.96**	10.20	13.13	9.70	**11.01**
	Mean	**9.75**	**11.37**	**9.40**	**10.17**	**9.61**	**11.37**	**9.63**	**10.20**	**9.68**	**11.37**	**9.51**	**10.18**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.057	0.168	0.049	0.145	0.037	0.108
M	0.070	0.205	0.50	0.178	0.046	0.133
I x M	0.099	0.291	0.86	0.252	0.065	0.188
W	0.057	0.168	0.049	0.145	0.037	0.108
I x W	0.081	0.237	0.070	0.206	0.053	0.150
M x W	0.099	0.291	0.086	0.252	0.065	NS
I x M x W	0.140	0.411	0.121	0.357	0.092	NS
CV %	13.39		11.07		14.23	

Table 1.8 Interaction effects between irrigation, method of N application and weed management on crop growth rate at 40 - 60 DAS

Method of N application → / Irrigation & weed management ↓		1995-96				1996-97				Pooled			
		M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	11.97	13.66	13.60	**13.07**	13.69	16.91	16.90	**15.83**	12.83	15.28	15.25	**14.45**
	W_2	13.02	16.55	13.81	**14.46**	14.85	17.05	16.58	**16.15**	13.93	16.79	15.19	**15.30**
	Mean	**12.49**	**15.10**	**13.70**	**13.76**	**14.27**	**16.97**	**16.74**	**15.99**	**13.38**	**16.04**	**15.22**	**14.88**
I_2	W_1	14.01	13.98	13.28	**13.75**	17.34	16.98	16.31	**16.87**	15.67	15.48	14.79	**15.31**
	W_2	13.00	18.83	14.15	**15.32**	16.51	22.07	16.84	**18.47**	14.75	20.45	15.49	**16.90**
	Mean	**13.50**	**16.40**	**13.71**	**14.54**	**16.92**	**19.52**	**16.57**	**17.67**	**15.21**	**17.96**	**15.14**	**16.10**
($I_1 + I_2$)	W_1	12.99	13.82	13.44	**13.41**	15.51	16.94	16.60	**16.35**	14.25	15.38	15.02	**14.88**
	W_2	13.01	17.69	13.98	**14.89**	15.68	19.55	16.71	**17.31**	14.34	18.62	15.34	**16.10**
	Mean	**13.00**	**15.75**	**13.71**	**14.15**	**13.59**	**18.25**	**16.65**	**16.83**	**14.29**	**17.00**	**15.18**	**15.49**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.029	0.085	0.040	0.129	0.026	0.076
M	0.035	0.105	0.054	0.158	0.032	0.093
I x M	0.050	0.148	0.076	0.224	0.045	0.131
W	0.029	0.085	0.044	0.129	0.026	0.076
I x W	0.041	0.121	0.062	0.183	0.037	0.107
M x W	0.050	0.148	0.076	0.224	0.045	0.131
I x M x W	0.071	0.210	0.108	0.317	0.064	0.186
CV %	12.88		13.11		12.03	

Table 1.9 Interaction effects between irrigation, method of N application and weed management on no. of siliqua per plant

Method of N application → / Irrigation & weed management ↓		1995-96				1996-97				Pooled			
		M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	134.96	219.66	166.93	**173.85**	168.70	216.33	315.43	**193.48**	151.83	218.00	181.83	**183.67**
	W_2	146.26	255.93	219.86	**207.35**	203.00	260.23	221.90	**228.37**	174.63	258.08	220.88	**217.86**
	Mean	**140.61**	**237.80**	**193.40**	**190.66**	**185.85**	**238.85**	**208.66**	**210.92**	**163.23**	**238.04**	**201.03**	**200.76**
I_2	W_1	221.93	234.50	216.33	**224.25**	217.10	237.50	219.90	**222.86**	219.56	236.00	218.11	**224.56**
	W_2	251.33	266.80	244.50	**254.21**	255.52	275.33	245.20	**258.68**	253.43	271.06	244.85	**256.45**
	Mean	**236.63**	**250.65**	**230.41**	**239.23**	**236.36**	**256.41**	**232.55**	**241.77**	**236.50**	**253.53**	**231.48**	**240.50**
($I_1 + I_2$)	W_1	178.45	227.08	191.63	**199.05**	192.95	226.91	207.66	**209.17**	185.70	227.00	199.65	**204.11**
	W_2	198.80	261.36	232.18	**230.78**	229.26	267.78	233.55	**243.53**	214.03	264.57	232.56	**237.15**
	Mean	**188.62**	**244.22**	**211.98**	**214.91**	**211.10**	**247.35**	**220.60**	**226.36**	**199.86**	**245.70**	**216.25**	**220.63**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	1.40	4.30	2.27	6.68	1.35	3.88
M	1.79	5.26	2.79	8.12	1.65	4.76
I x M	2.54	7.45	3.94	11.57	2.34	6.73
W	1.46	4.30	2.27	6.68	1.35	3.88
I x W	2.07	6.08	3.22	9.44	1.91	NS
M x W	2.54	7.45	3.94	NS	2.34	NS
I x M x W	3.59	10.53	5.58	16.36	3.31	9.52
CV %	12.90		13.27		13.68	

Table 1.10 Interaction effects between irrigation, method of N application and weed management on no. of seeds per siliquae

Method of N application → Irrigation & weed management ↓		1995-96				1996-97				Pooled			
		M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	11.96	13.73	12.86	**12.85**	12.06	13.86	12.93	**12.95**	12.01	13.80	12.90	**12.90**
	W_2	12.90	15.73	13.53	**14.05**	13.06	16.33	14.46	**14.62**	12.98	16.03	14.00	**14.33**
	Mean	**12.43**	**14.73**	**13.20**	**13.45**	**12.56**	**15.10**	**13.70**	**13.78**	**12.50**	**14.91**	**13.45**	**13.62**
I_2	W_1	13.53	14.03	13.90	**13.82**	14.23	14.86	14.23	**14.44**	13.88	14.45	14.06	**14.13**
	W_2	15.16	16.86	14.06	**15.36**	15.66	17.46	15.80	**16.31**	15.41	17.16	14.93	**15.83**
	Mean	**14.35**	**15.45**	**13.98**	**14.59**	**14.95**	**16.16**	**15.01**	**15.37**	**14.65**	**15.80**	**14.50**	**14.98**
$(I_1 + I_2)$	W_1	12.75	13.88	13.38	**13.33**	13.15	14.36	13.58	**13.70**	12.95	14.12	13.48	**13.51**
	W_2	14.03	16.30	13.80	**14.71**	14.36	16.90	15.13	**15.46**	14.20	16.60	14.46	**15.08**
	Mean	**13.39**	**15.09**	**13.59**	**14.02**	**13.75**	**15.63**	**14.35**	**14.58**	**13.57**	**15.36**	**13.97**	**14.30**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.056	0.165	0.071	0.209	0.045	0.130
M	0.068	0.202	0.087	0.256	0.055	0.159
I x M	0.097	0.285	0.143	0.361	0.078	0.225
W	0.056	0.165	0.071	0.209	0.045	0.130
I x W	0.079	0.233	0.100	NS	0.064	NS
M x W	0.097	0.285	0.123	0.361	0.078	0.225
I x M x W	0.137	0.404	0.174	0.512	0.112	0.319
CV %	11.70		12.07		11.90	

Table 1.11 Interaction effects between irrigation, method of N application and weed management on stover yield

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	1651.36	3175.94	2680.12	**2502.47**	1996.70	3046.79	2839.30	**2600.90**	1784.03	311.37	2759.66	**2551.69**
	W_2	2670.81	3849.03	2833.97	**3117.94**	2768.70	4261.22	3066.13	**3365.34**	2719.76	4055.13	2950.04	**3241.64**
	Mean	**2161.09**	**3512.49**	**2757.04**	**2810.21**	**2342.70**	**3654.01**	**2952.66**	**2983.12**	**2251.89**	**3583.25**	**2854.85**	**2896.66**
I_2	W_1	2922.86	3009.82	2988.08	**2973.58**	3228.91	3353.88	3120.05	**3234.28**	3075.88	3181.85	3054.07	**3103.93**
	W_2	3628.92	4379.44	3237.60	**3748.65**	3740.13	4741.79	3499.33	**3993.75**	3684.52	4562.62	3768.47	**3871.20**
	Mean	**3275.89**	**3694.63**	**3112.84**	**3361.12**	**3484.52**	**4047.83**	**3309.69**	**3614.01**	**3380.20**	**3871.23**	**3211.27**	**3487.57**
($I_1 + I_2$)	W_1	2287.11	3092.88	2834.10	**2738.03**	2572.80	3200.33	2979.63	**2917.59**	2429.96	3146.61	2906.86	**2827.81**
	W_2	3149.86	4114.24	3035.79	**3433.30**	3254.42	4501.51	3282.72	**3679.55**	3202.14	4307.87	3159.25	**3556.42**
	Mean	**2718.49**	**3603.56**	**2934.94**	**3085.66**	**2913.61**	**3850.92**	**3131.17**	**3298.57**	**2816.05**	**3727.24**	**3033.06**	**3192.11**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	44.33	130.01	29.01	85.09	26.49	76.04
M	54.29	159.23	35.53	104.22	32.44	93.13
I x M	76.78	225.19	50.25	147.39	45.88	131.71
W	44.33	130.01	29.01	85.09	26.49	76.04
I x W	62.69	NS	41.03	NS	37.46	NS
M x W	76.78	225.19	50.25	147.39	45.88	131.71
I x M x W	108.59	318.47	71.07	208.44	64.89	186.27
CV%	13.10		13.73		12.98	

Table 1.12 Interaction effects between irrigation, method of N application and weed management on harvest index

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management ↓	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	19.94	22.18	20.43	**21.02**	19.95	23.48	21.34	**21.59**	19.94	22.83	21.13	**21.30**
	W_2	19.84	27.76	24.29	**23.96**	20.49	27.49	24.38	**24.12**	20.17	27.63	24.33	**24.04**
	Mean	**19.89**	**24.97**	**22.61**	**22.49**	**20.22**	**25.49**	**22.86**	**22.85**	**20.05**	**25.23**	**22.73**	**22.67**
I_2	W_1	23.65	25.32	23.30	**24.09**	22.44	25.13	23.93	**23.83**	23.04	25.22	23.61	**23.96**
	W_2	26.49	28.55	26.16	**27.07**	26.96	28.67	25.83	**27.15**	26.73	28.61	26.00	**27.11**
	Mean	**25.07**	**26.93**	**24.73**	**25.58**	**24.70**	**26.90**	**24.88**	**25.49**	**24.88**	**26.93**	**24.80**	**25.53**
$(I_1 + I_2)$	W_1	21.79	23.75	22.11	**22.55**	21.19	24.30	22.63	**22.71**	21.49	24.03	22.37	**22.63**
	W_2	23.16	28.16	25.22	**25.51**	23.73	28.08	25.10	**25.64**	23.45	28.12	25.16	**25.58**
	Mean	**22.48**	**25.95**	**23.67**	**24.03**	**22.46**	**26.18**	23.87	**24.17**	22.47	**26.07**	**23.77**	**24.10**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.295	0.866	0.149	0.439	0.165	0.475
M	0.361	1.06	0.183	0.537	0.202	0.582
I x M	0.511	1.50	0.259	0.760	0.286	0.823
W	0.295	0.866	0.149	0.439	0.165	0.475
I x W	0.417	NS	0.211	NS	0.234	NS
M x W	0.511	1.50	0.259	0.760	0.286	0.823
I x M x W	0.723	NS	0.366	NS	0.405	NS
CV %	13.21		12.63		14.12	

Table 1.13 Interaction effects between irrigation, method of N application and weed management on oil content (%)

Method of N application →		1995-96				1996-97				Pooled			
Irrigation ↓	& weed management ↓	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean	M_1	M_2	M_3	Mean
I_1	W_1	37.80	38.45	37.87	**38.04**	38.28	38.52	38.50	**38.43**	38.04	38.48	**38.17**	**38.24**
	W_2	37.86	39.93	38.36	**38.72**	38.18	39.97	39.00	**39.05**	38.02	39.95	38.68	**38.88**
	Mean	**37.83**	**39.19**	**38.11**	**38.38**	**38.23**	**39.25**	**38.75**	**38.74**	**38.03**	**39.22**	**38.43**	**38.56**
I_2	W_1	38.39	39.08	38.23	**38.56**	38.66	39.23	38.39	**38.76**	38.52	39.15	38.31	**38.66**
	W_2	39.65	40.14	39.33	**39.71**	39.74	40.08	39.30	**39.70**	39.69	40.11	39.31	**39.70**
	Mean	**39.02**	**39.61**	**38.78**	**38.13**	**39.20**	**39.65**	**38.84**	**39.23**	**39.11**	**39.63**	**38.81**	**39.18**
($I_1 + I_2$)	W_1	38.09	38.76	38.05	**38.30**	38.47	38.87	38.45	**38.60**	38.28	38.82	38.25	**38.45**
	W_2	38.76	40.03	38.85	**39.21**	38.96	40.03	39.15	**39.38**	38.86	40.03	39.00	**39.29**
	Mean	**38.42**	**39.40**	**38.45**	**38.76**	**38.71**	**39.45**	**38.80**	**38.99**	**38.57**	**39.47**	**38.62**	**38.87**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
I	0.50	NS	0.083	NS	0.048	NS
M	0.061	NS	0.102	NS	0.059	NS
I x M	0.086	NS	0.144	NS	0.084	NS
W	0.050	NS	0.083	NS	0.048	NS
I x W	0.070	NS	0.117	NS	0.068	NS
M x W	0.086	NS	0.144	NS	0.084	NS
I x M x W	0.122	NS	0.203	NS	0.119	NS
CV %	10.55		10.91		10.75	

Table 2.1 Interaction effects between spacing, method of N application and weed management on no. of primary branches per plant of rainfed mustard

Method of N application → / Spacing & weed management ↓		1995-96				1996-97				Pooled			
		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	4.17	4.55	4.52	**4.41**	4.60	5.13	5.19	**4.97**	4.38	4.84	4.85	**4.69**
	W'_2	4.49	5.62	5.00	**5.03**	4.90	6.11	5.62	**5.54**	4.69	5.86	5.31	**5.29**
	Mean	**4.33**	**5.08**	**4.76**	**4.72**	**4.75**	**5.62**	**5.42**	**5.26**	**4.54**	**5.35**	**5.08**	**4.99**
S_2	W'_1	4.88	5.78	4.91	**5.19**	5.59	6.22	6.00	**5.94**	5.24	6.00	5.46	**5.56**
	W'_2	5.96	6.38	5.89	**6.07**	6.15	6.88	6.34	**6.46**	6.05	6.63	6.11	**6.26**
	Mean	**5.42**	**6.08**	**5.40**	**5.63**	**5.87**	**6.55**	**6.17**	**6.20**	**6.64**	**6.31**	**5.78**	**5.91**
$(S_1 + S_2)$	W'_1	4.52	5.16	4.71	**4.80**	5.10	5.67	5.60	**5.45**	4.81	5.42	5.15	**5.13**
	W'_2	5.22	6.00	5.44	**5.50**	5.53	6.49	5.98	**6.00**	5.37	6.24	5.71	**5.78**
	Mean	**4.87**	**5.58**	**5.08**	**5.18**	**5.31**	**6.08**	**5.97**	**5.73**	**5.09**	**5.83**	**5.43**	**5.45**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	Sem (±)	CD (P=0.05)
S	0.044	0.129	0.052	0.154	0.034	0.098
M'	0.054	0.158	0.064	0.189	0.042	0.120
$S \times M'$	0.076	0.224	0.091	NS	0.059	0.170
W'	0.044	0.129	0.052	0.154	0.034	0.098
$S \times W'$	0.062	NS	0.074	NS	0.048	NS
$M' \times W'$	0.076	NS	0.091	NS	0.059	NS
$S \times M' \times W'$	0.108	0.318	0.129	NS	0.084	0.241
CV %	13.16		13.90		13.78	

Table 2.2 Interaction effects between spacing, method of N application and weed management on no. of secondary branches per plant of raindfed

Method of N application → / Spacing & weed management ↓		1995-96				1996-97				Pooled			
		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	5.53	6.09	6.11	**5.91**	5.86	6.65	7.35	**6.62**	5.69	6.37	6.73	**6.26**
	W'_2	5.70	7.196	6.31	**6.40**	6.23	7.58	7.42	**7.08**	5.96	7.38	6.87	**6.74**
	Mean	**5.61**	**6.64**	**6.21**	**6.15**	**6.04**	**7.11**	**7.39**	**6.85**	**5.83**	**6.88**	**6.80**	**6.50**
S_2	W'_1	6.37	7.28	6.28	**6.64**	7.68	7.74	7.67	**7.70**	7.03	7.51	6.97	**7.17**
	W'_2	7.33	8.46	7.33	**7.70**	7.81	8.64	8.27	**8.24**	7.57	8.55	7.80	**7.97**
	Mean	**6.85**	**7.87**	**6.80**	**7.17**	**7.74**	**8.19**	**7.97**	**7.97**	**7.30**	**8.03**	**7.39**	**7.57**
$(S_1 + S_2)$	W'_1	5.95	6.69	6.19	**6.28**	6.77	7.20	7.51	**7.16**	6.36	6.94	6.85	**6.72**
	W'_2	6.51	7.81	6.81	**7.05**	7.02	8.11	7.85	**7.66**	6.76	7.96	7.33	**7.35**
	Mean	**6.23**	**7.25**	**6.51**	**6.66**	**6.89**	**7.65**	**7.68**	**7.41**	**6.56**	**7.45**	**7.09**	**7.04**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	Sem (±)	CD (P=0.05)
S	0.046	0.136	0.061	0.171	0.038	0.110
M'	0.057	0.167	0.074	0.219	0.047	0.135
S x M'	0.080	0.236	0.105	0.310	0.066	0.190
W'	0.046	0.136	0.61	0.179	0.038	0.110
S x W'	0.065	0.192	0.086	NS	0.054	0.155
M' x W'	0.080	0.236	0.105	0.310	0.066	0.190
S x M' x W'	0.114	0.334	0.149	0.439	0.094	0.270
CV %	12.96		13.50		13.27	

Table 2.3 Interaction effects between spacing, method of N application and weed management on leaf area index at 20 DAS of rainfed mustard

Method of N application → / Spacing & weed management ↓		1995-96 M'_1	1995-96 M'_2	1995-96 M'_3	1995-96 Mean	1996-97 M'_1	1996-97 M'_2	1996-97 M'_3	1996-97 Mean	Pooled M'_1	Pooled M'_2	Pooled M'_3	Pooled Mean
S_1	W'_1	0.182	0.188	0.190	**0.187**	0.172	0.190	0.188	**0.183**	0.177	0.189	0.189	**0.185**
	W'_2	0.172	0.246	0.196	**0.205**	0.180	0.260	0.205	**0.215**	0.176	0.253	0.201	**0.210**
	Mean	**0.177**	**0.217**	**0.193**	**0.196**	**0.176**	**0.225**	**0.197**	**0.199**	**0.176**	**0.221**	**0.195**	**0.197**
S_2	W'_1	0.202	0.250	0.202	**0.218**	0.210	0.272	0.198	**0.227**	0.206	0.261	0.200	**0.222**
	W'_2	0.252	0.218	0.258	**0.269**	0.260	0.310	0.267	**0.249**	0.256	0.304	0.262	**0.274**
	Mean	**0.227**	**0.274**	**0.230**	**0.244**	**0.235**	**0.291**	**0.232**	**0.253**	**0.231**	**0.282**	**0.231**	**0.248**
($S_1 + S_2$)	W'_1	0.192	0.219	0.196	**0.202**	0.191	0.230	0.193	**0.205**	0.191	0.225	0.194	**0.204**
	W'_2	0.212	0.272	0.227	**0.237**	0.220	0.280	.236	**0.247**	0.216	0.278	0.231	**0.242**
	Mean	**0.202**	**0.245**	**0.211**	**0.220**	**0.205**	**0.258**	**0.215**	**0.226**	**0.204**	**0.252**	**0.213**	**0.223**

	1995-96 SEm (±)	1995-96 CD (P=0.05)	1996-97 SEm (±)	1996-97 CD (P=0.05)	Pooled SEm (±)	Pooled CD (P=0.05)
S	0.002	0.005	0.001	0.003	0.001	0.003
M'	0.002	0.007	0.001	0.004	0.001	0.004
S x M'	0.003	0.010	0.002	0.006	0.002	0.006
W'	0.002	0.005	0.001	0.003	0.001	0.003
S x W'	0.002	0.008	0.001	0.005	0.001	0.004
M' x W'	0.003	0.010	0.002	0.006	0.002	0.006
S x M' x W'	0.005	0.014	0.003	0.009	0.003	0.008
CV %	13.91		12.46		13.25	

Table 2.4 Interaction effects between spacing, method of N application and weed management on leaf area index at 40 DAS of rainfed mustard

Method of N application → / Spacing & weed management ↓		1995-96 M'_1	1995-96 M'_2	1995-96 M'_3	1995-96 Mean	1996-97 M'_1	1996-97 M'_2	1996-97 M'_3	1996-97 Mean	Pooled M'_1	Pooled M'_2	Pooled M'_3	Pooled Mean
S_1	W'_1	0.828	1.02	1.20	**1.01**	0.872	0.989	1.02	**0.960**	0.850	1.00	1.11	**0.988**
	W'_2	0.972	1.62	1.23	**1.27**	0.928	1.78	1.20	**1.30**	0.950	1.70	1.21	**1.28**
	Mean	**0.900**	**1.32**	**1.21**	**1.14**	**0.900**	**1.38**	**1.11**	**1.13**	**0.900**	**1.35**	**1.16**	**1.13**
S_2	W'_1	1.32	1.62	1.22	**1.38**	1.20	1.30	1.22	**1.24**	1.26	1.46	1.22	**1.31**
	W'_2	1.68	1.97	1.30	**1.65**	1.25	1.90	1.36	**1.50**	1.46	1.93	1.33	**1.57**
	Mean	**1.30**	**1.79**	**1.26**	**1.51**	**1.22**	**1.60**	**1.29**	**1.37**	**1.36**	**1.69**	**1.27**	**1.44**
$(S_1 + S_2)$	W'_1	1.07	1.32	1.21	**1.20**	1.03	1.14	1.12	**1.10**	1.05	1.23	1.16	**1.51**
	W'_2	1.32	1.97	1.26	**1.46**	1.08	1.84	1.28	**1.40**	1.20	1.81	1.27	**1.43**
	Mean	**1.20**	**1.55**	**1.23**	**1.33**	**1.06**	**1.49**	**1.20**	**1.25**	**1.13**	**1.52**	**1.21**	**1.29**

	1995-96 SEm (±)	1995-96 CD (P=0.05)	1996-97 SEm (±)	1996-97 CD (P=0.05)	Pooled SEm (±)	Pooled CD (P=0.05)
S	0.011	0.032	0.011	0.032	0.007	0.022
M'	0.013	0.040	0.013	0.039	0.009	0.027
S x M'	0.019	0.056	0.019	0.055	0.013	0.039
W'	0.011	0.032	0.011	0.032	0.007	0.022
S x W'	0.015	NS	0.015	0.45	0.011	NS
M' x W'	0.019	0.056	0.019	0.055	0.013	0.039
S x M' x W'	0.027	0.080	0.026	NS	0.019	0.055
CV %	13.75		13.72		13.64	

Table 2.5 : Interaction effects between spacing, method of N application and weed management on leaf area index at 60 DAS of rainfed mustard.

Method of N application →		1995-96				1996-97				Pooled			
Spicing & weed management ↓		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	4.08	4.77	4.88	**4.57**	4.10	4.82	4.90	**4.60**	4.09	4.79	4.89	**4.59**
	W'_2	4.62	5.66	4.76	**5.01**	4.52	5.72	4.86	**5.03**	4.57	5.69	4.81	**5.02**
	Mean	**4.35**	**5.21**	**4.82**	**4.79**	**4.31**	**5.27**	**4.88**	**4.82**	**4.33**	**5.24**	**4.85**	**4.80**
S_2	W'_1	4.88	5.07	5.10	**5.01**	5.12	5.20	5.26	**5.18**	5.00	5.16	5.14	**5.10**
	W'_2	4.92	5.98	5.20	**5.36**	6.02	5.18	5.15	**5.45**	5.06	6.06	5.17	**5.41**
	Mean	**4.90**	**5.52**	**5.15**	**5.19**	**5.16**	**5.64**	**5.16**	**5.32**	**5.03**	**5.58**	**5.15**	**5.25**
$(S_1 + S_2)$	W'_1	4.48	4.92	4.99	**4.79**	4.61	5.04	5.04	**4.89**	4.54	4.98	5.01	**4.84**
	W'_2	4.77	5.82	4.98	**5.19**	4.86	5.87	5.00	**5.24**	4.81	5.84	4.99	**5.21**
	Mean	**4.62**	**5.37**	**4.98**	**4.99**	**4.73**	**5.45**	**5.02**	**5.07**	**4.68**	**5.41**	**5.00**	**5.21**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	0.015	0.045	0.007	0.022	0.008	0.025
M'	0.019	0.056	0.009	0.028	0.010	0.030
S x M'	0.027	0.079	0.013	0.039	0.015	0.042
W'	0.015	0.045	0.007	0.022	0.008	0.025
S x W'	0.022	NS	0.011	0.032	0.012	0.035
M' x W'	0.027	0.079	0.013	0.039	0.015	0.043
S x M' x W'	0.038	0.112	0.019	0.056	0.021	0.061
CV %	11.33		10.66		11.04	

Table 2.6 Interaction effects between spacing, method of N application and weed management on leaf area index at 80 DAS of rainfed mustard

Method of N application →		1995-96				1996-97				Pooled			
Spacing & weed management ↓		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	1.56	1.69	1.56	**1.60**	1.48	1.72	1.62	**1.60**	1.52	1.70	1.59	**1.60**
	W'_2	1.68	2.12	1.36	**1.72**	1.69	2.18	1.42	**1.76**	1.68	2.15	1.39	**1.74**
	Mean	**1.62**	**1.90**	**1.46**	**1.66**	**1.58**	**1.95**	**1.52**	**1.68**	**1.60**	**1.92**	**1.49**	**1.67**
S_2	W'_1	1.52	1.98	1.77	**1.75**	1.39	1.72	1.90	**1.67**	1.45	1.85	1.83	**1.71**
	W'_2	1.68	2.33	1.55	**1.85**	1.48	2.45	1.63	**1.85**	1.58	2.39	1.59	**1.85**
	Mean	**1.60**	**2.15**	**1.66**	**1.80**	**1.43**	**2.08**	**1.76**	**1.76**	**1.51**	**2.12**	**1.71**	**1.65**
($S_1 + S_2$)	W'_1	1.54	1.83	1.66	**1.68**	1.43	1.72	1.76	**1.63**	1.48	1.77	1.71	**1.65**
	W'_2	1.68	2.22	1.45	**1.78**	1.58	2.31	1.52	**1.80**	1.63	2.27	1.49	**1.79**
	Mean	**1.61**	**2.03**	**1.56**	**1.73**	**1.51**	**2.01**	**1.64**	**1.72**	**1.56**	**2.02**	**1.60**	**1.72**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	0.010	0.030	0.011	0.033	0.007	0.022
M'	0.012	0.036	0.014	0.041	0.009	0.026
S x M'	0.017	0.052	0.019	0.058	0.013	0.038
W'	0.010	0.030	0.011	0.033	0.007	0.022
S x W'	0.014	NS	0.016	NS	0.010	NS
M' x W'	0.017	0.052	0.019	0.058	0.013	0.038
S x M' x W'	0.025	NS	0.028	0.082	0.018	0.053
CV %	12.51		12.81		12.66	

Table 2.7 Interaction effects between spacing, method of N application and weed management on crop growth rate at 20 - 40 DAS of rainfed mustard

Method of N application → / Spacing & weed management ↓		1995-96				1996-97				Pooled			
		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	8.89	8.94	9.50	**9.11**	8.78	9.54	9.57	**9.25**	8.83	9.24	9.53	**9.20**
	W'_2	8.85	9.95	9.63	**9.47**	9.02	10.18	9.35	**9.51**	8.93	10.06	9.49	**9.49**
	Mean	**8.87**	**9.44**	**9.56**	**9.24**	**8.90**	**9.86**	**9.46**	**9.40**	**8.88**	**9.65**	**9.51**	**9.35**
S_2	W'_1	9.67	9.90	9.61	**9.72**	9.40	10.16	9.66	**9.64**	9.53	10.03	9.48	**9.68**
	W'_2	9.91	10.23	9.50	**10.03**	10.11	10.36	10.10	**10.19**	10.01	10.29	10.02	**10.11**
	Mean	**9.79**	**10.06**	**9.78**	**9.87**	**9.75**	**10.26**	**+9.73**	**9.91**	**9.77**	**10.67**	**9.75**	**9.89**
($S_1 + S_2$)	W'_1	9.28	9.42	9.55	**9.41**	9.09	9.85	9.46	**9.46**	9.18	9.63	9.51	**9.44**
	W'_2	9.38	10.09	9.79	**9.74**	9.56	10.27	9.72	**9.83**	9.47	10.18	9.75	**9.80**
	Mean	**9.33**	**9.75**	**9.67**	**9.58**	**9.32**	**10.06**	**9.59**	**9.66**	**9.32**	**9.90**	**9.63**	**9.62**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	0.027	0.079	0.021	0.067	0.017	0.051
M'	0.033	0.096	0.028	0.082	0.021	0.062
S x M'	0.046	0.137	0.040	0.117	0.030	0.088
W'	0.027	0.079	0.023	0.067	0.017	0.051
S x W'	0.038	NS	0.032	NS	0.025	0.072
M' x W'	0.046	0.137	0.040	0.117	0.030	0.088
S x M' x W'	0.066	0.194	0.565	0.165	0.043	0.125
CV %	11.20		12.01		13.11	

Table 2.8 Interaction effects between spacing, method of N application and weed management on crop growth rate at 40 - 60 DAS of rainfed mustard

Method of N application → / Spacing & weed management ↓		1995-96				1996-97				Pooled			
		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	12.00	13.36	13.54	**12.96**	12.96	13.49	13.50	**13.31**	12.48	13.42	13.52	**13.14**
	W'_2	12.90	14.93	13.69	**13.84**	12.95	14.99	13.69	**13.87**	12.92	14.96	13.69	**13.85**
	Mean	**12.45**	**14.14**	**13.61**	**13.40**	**12.95**	**14.24**	**13.59**	**13.59**	**12.70**	**14.19**	**13.60**	**13.50**
S_2	W'_1	13.65	14.95	13.68	**14.09**	13.71	15.06	13.69	**14.15**	13.68	15.00	13.68	**14.12**
	W'_2	14.95	15.13	14.93	**15.00**	15.08	15.10	15.13	**15.10**	15.01	15.11	15.03	**15.05**
	Mean	**14.30**	**15.04**	**14.30**	**14.54**	**14.39**	**15.08**	**14.41**	**14.62**	**14.34**	**15.06**	**14.35**	**14.58**
($S_1 + S_2$)	W'_1	12.82	14.95	13.61	**13.53**	13.33	14.27	13.59	**13.73**	13.08	14.21	13.60	**13.63**
	W'_2	13.92	15.03	14.31	**14.42**	14.01	15.04	14.41	**14.49**	13.97	15.03	14.63	**14.45**
	Mean	**13.37**	**14.59**	**13.96**	**13.97**	**13.67**	**14.66**	**14.00**	**14.11**	**13.52**	**14.62**	**13.98**	**14.04**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	0.035	0.103	0.042	0.124	0.027	0.079
M'	0.043	0.127	0.051	0.152	0.033	0.097
S x M'	0.061	0.179	0.073	0.215	0.047	0.137
W'	0.035	0.103	0.042	0.124	0.027	0.079
S x W'	0.050	NS	0.060	NS	0.039	0.112
M' x W'	0.061	NS	0.073	NS	0.047	NS
S x M' x W'	0.086	0.254	0.103	0.304	0.067	0.194
CV %	11.08		12.27		11.18	

Table 2.9 Interaction effects between spacing, method of N application and weed management on no. of siliqua per plant of rainfed mustard

Method of N application → / Spacing & weed management ↓		1995-96				1996-97				Pooled			
		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	148.63	187.86	195.73	**177.41**	155.23	200.83	205.60	**187.22**	151.93	194.35	200.66	**182.31**
	W'_2	172.50	242.06	206.90	**207.82**	177.46	251.40	218.36	**215.74**	174.98	246.73	213.63	**211.78**
	Mean	**160.56**	**214.96**	**202.31**	**192.61**	**166.35**	**226.11**	**211.98**	**201.48**	**163.45**	**220.54**	**207.15**	**197.05**
S_2	W'_1	211.26	244.33	209.66	**221.75**	220.00	253.90	217.76	**230.55**	215.63	249.11	213.71	**226.15**
	W'_2	242.70	247.70	241.93	**244.11**	252.70	257.16	250.16	**253.34**	247.70	252.43	246.05	**248.12**
	Mean	**226.98**	**246.01**	**225.80**	**232.93**	**236.35**	**255.53**	**233.96**	**241.95**	**231.66**	**250.77**	**229.88**	**237.44**
$(S_1 + S_2)$	W'_1	179.95	216.10	202.70	**199.58**	187.61	227.36	211.68	**208.88**	183.78	221.73	207.19	**204.23**
	W'_2	207.60	244.88	225.41	**225.96**	215.08	254.28	234.26	**234.54**	211.34	249.58	229.84	**230.25**
	Mean	**193.77**	**230.49**	**214.05**	**212.77**	**201.35**	**240.82**	**222.97**	**221.71**	**197.56**	**235.65**	**218.51**	**217.24**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	1.17	3.43	1.09	3.21	0.802	2.30
M'	1.43	4.20	1.34	3.93	0.982	2.82
S x M'	2.02	5.95	1.89	5.57	1.38	3.98
W'	1.17	3.43	1.09	3.21	0.802	2.30
S x W'	1.65	4.85	1.55	NS	1.13	3.25
M' x W'	2.02	NS	1.89	NS	1.38	NS
S x M' x W'	2.86	8.41	2.68	7.87	1.96	5.64
CV %	13.34		14.10		13.22	

Table 2.10 Interaction effects between spacing, method of N application and weed management on no. of seeds per siliquae of rainfed mustard

Method of N application →		1995-96				1996-97				Pooled			
Spacing & weed management ↓		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	12.43	13.46	13.63	**13.17**	12.73	13.50	13.46	**13.23**	12.58	13.48	13.55	**13.20**
	W'_2	13.50	15.03	13.83	**14.21**	13.46	15.06	13.66	**14.06**	13.48	15.05	13.75	**14.09**
	Mean	**12.96**	**14.25**	**13.73**	**13.65**	**13.10**	**14.28**	**13.56**	**13.65**	**13.03**	**14.26**	**13.65**	**13.65**
S_2	W'_1	13.83	14.70	13.60	**14.04**	13.66	15.06	13.73	**14.15**	13.75	14.88	13.66	**14.10**
	W'_2	14.63	15.73	14.73	**15.03**	15.03	15.93	15.03	**15.33**	14.83	15.83	14.88	**15.18**
	Mean	**14.23**	**15.21**	**14.16**	**14.53**	**14.35**	**15.50**	**14.38**	**14.74**	**14.29**	**15.35**	**14.27**	**14.64**
($S_1 + S_2$)	W'_1	13.13	14.08	13.61	**13.61**	13.20	14.28	13.60	**13.69**	13.16	14.18	13.60	**13.65**
	W'_2	14.06	15.38	14.28	**14.57**	14.25	15.50	14.35	**14.70**	14.15	15.44	14.31	**14.63**
	Mean	**13.60**	**14.73**	**13.95**	**14.09**	**13.72**	**14.89**	**13.97**	**14.19**	**13.66**	**14.84**	**13.96**	**14.14**

	1995-96 SEm (±)	1995-96 CD (P=0.05)	1996-97 SEm (±)	1996-97 CD (P=0.05)	Pooled SEm (±)	Pooled CD (P=0.05)
S	0.067	0.197	0.057	0.168	0.044	0.127
M'	0.082	0.242	0.070	0.206	0.054	0.155
S x M'	0.116	0.342	0.099	NS	0.076	0.220
W'	0.067	0.197	0.057	0.168	0.044	0.127
S x W'	0.095	NS	0.081	NS	0.062	NS
M' x W'	0.116	0.342	0.099	NS	0.076	0.220
S x M' x W'	0.165	0.484	0.140	0.412	0.108	0.311
CV %	12.03		11.72		11.88	

Table 2.11 Interaction effects between spacing, method of N application and weed management on stover yield (kg/ha) of rainfed mustard

Method of N application →		1995-96				1996-97				Pooled			
Spacing & weed management ↓		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	2203.84	2641.30	2644.35	**2496.50**	2664.75	3058.86	2872.29	**2865.30**	2434.30	2850.08	2758.32	**2680.90**
	W'_2	2542.64	2981.84	2751.41	**2758.63**	2724.81	3214.95	2982.30	**2974.02**	2633.73	3098.39	3866.85	**2866.32**
	Mean	**2373.24**	**2811.57**	**2697.88**	2627.56	**2694.78**	**3136.90**	**2927.29**	2919.66	**2534.01**	**2974.24**	**2812.59**	2773.61
S_2	W'_1	2657.16	3167.16	2849.95	**2891.42**	3155.29	3511.67	3133.63	**3266.86**	2906.23	3339.41	2991.79	**3079.14**
	W'_2	3048.17	3093.46	2857.87	**2999.50**	3581.14	3374.07	3359.97	**3438.39**	3314.65	3233.76	3108.42	**3218.95**
	Mean	**2852.67**	**3130.31**	**2853.41**	2945.46	**3368.21**	**3442.87**	**3246.80**	3352.63	**3110.44**	**3286.59**	**3050.10**	3149.04
($S_1 + S_2$)	W'_1	2430.50	2904.23	2747.15	**2693.96**	2910.02	3285.27	3002.96	**3066.08**	2670.26	3094.75	2875.05	**2880.02**
	W'_2	2795.41	3037.65	2804.14	**2879.06**	3152.97	3294.51	3171.14	**3206.21**	2974.19	3166.08	2987.64	**3042.64**
	Mean	**2612.95**	**2970.95**	**2775.64**	2786.51	**3031.50**	**3289.89**	**3087.05**	3136.14	**2822.23**	**3130.41**	**2931.35**	2961.33

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	9.43	27.66	7.92	23.24	6.16	17.68
M'	11.55	33.88	9.70	28.47	7.54	21.65
S x M'	16.33	47.91	13.73	40.26	10.67	30.63
W'	9.43	27.66	7.92	23.24	6.16	17.68
S x W'	13.34	39.12	11.21	32.87	8.71	25.01
M' x W'	16.33	47.91	13.73	40.26	10.67	30.63
S x M' x W'	26.10	67.76	19.41	56.94	15.09	43.31
CV %	11.44		11.07		11.25	

Table 2.12 Interaction effects between spacing, method of N application and weed management on harvest index of rainfed mustard

Method of N application → / Spacing & weed management ↓		1995-96				1996-97				Pooled			
		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	19.55	22.58	23.35	**21.84**	20.12	22.19	23.34	**21.88**	19.84	22.39	**23.36**	**21.80**
	W'_2	20.54	27.33	24.30	**24.09**	21.80	27.56	24.88	**24.75**	21.17	27.45	24.59	**24.40**
	Mean	**20.05**	**24.96**	**23.84**	**22.95**	**20.96**	**24.88**	**24.11**	**23.31**	**20.50**	**24.92**	**23.98**	**23.92**
S_2	W'_1	25.00	26.13	23.69	**24.94**	23.80	25.83	22.62	**24.08**	24.40	25.98	23.15	**24.51**
	W'_2	26.88	28.46	28.11	**27.83**	25.45	28.33	26.69	**26.82**	26.17	28.41	27.40	**27.33**
	Mean	**25.94**	27.31	**25.90**	**26.38**	**24.62**	**27.08**	**24.65**	**25.45**	**25.28**	**27.20**	**25.28**	**25.92**
($S_1 + S_2$)	W'_1	22.28	24.36	23.53	23.39	21.96	24.01	22.98	**22.98**	22.12	24.18	23.26	**23.19**
	W'_2	23.71	27.91	26.21	**25.94**	23.62	27.97	25.79	**25.78**	23.67	27.93	26.00	**25.86**
	Mean	**22.99**	26.13	**24.87**	**24.67**	**22.79**	**25.98**	24.38	**24.38**	22.89	**26.06**	**24.63**	**24.52**

	1995-96 SEm (±)	1995-96 CD (P=0.05)	1996-97 SEm (±)	1996-97 CD (P=0.05)	Pooled SEm (±)	Pooled CD (P=0.05)
S	0.142	0.417	0.199	0.584	0.122	0.351
M'	0.174	0.512	0.244	0.715	0.150	0.430
S x M'	0.247	0.724	0.345	1.01	0.212	0.609
W'	0.142	0.417	0.199	0.584	0.122	0.351
S x W'	0.201	NS	0.281	NS	0.173	NS
M' x W'	0.247	0.724	0.345	1.01	0.212	0.609
S x M' x W'	0.349	1.02	0.488	1.43	0.300	0.861
CV %	12.45		13.47		13.00	

Table 2.13 Interaction effects between spacing, method of N application and weed management on oil content (%) of rainfed mustard

Method of N application →		1995-96				1996-97				Pooled			
Spacing & weed management ↓		M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean	M'_1	M'_2	M'_3	Mean
S_1	W'_1	37.80	38.92	38.59	**38.43**	38.11	38.44	38.59	**38.38**	37.95	38.68	38.59	**38.41**
	W'_2	38.22	39.65	39.03	**38.97**	37.89	39.79	39.41	**39.03**	38.05	39.72	39.22	**39.00**
	Mean	**38.01**	**39.28**	**38.81**	**38.70**	**38.00**	**39.11**	**39.00**	**38.70**	**38.00**	**39.20**	**38.90**	**38.70**
S_2	W'_1	39.11	39.85	39.31	**39.42**	39.52	40.06	39.17	**39.58**	39.31	39.95	39.24	**39.50**
	W'_2	39.67	40.11	39.65	**39.81**	39.78	40.14	39.62	**39.85**	39.72	40.13	39.64	**39.83**
	Mean	**39.37**	**39.9**	**39.48**	**39.61**	**39.65**	**40.10**	**39.39**	**39.71**	**39.52**	**40.04**	**39.44**	**39.66**
($S_1 + S_2$)	W'_1	38.45	39.38	38.95	38.93	38.82	39.25	38.88	**38.98**	38.63	39.31	38.91	**38.95**
	W'_2	38.94	39.88	39.34	**39.39**	38.83	39.97	39.52	**39.44**	38.89	39.92	39.43	**39.41**
	Mean	**38.70**	**39.63**	**39.15**	**39.16**	**38.82**	**39.31**	**39.20**	**39.21**	**38.76**	**39.62**	**39.17**	**39.18**

	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)	SEm (±)	CD (P=0.05)
S	0.086	NS	0.071	NS	0.056	NS
M'	0.105	NS	0.087	NS	0.068	NS
$S \times M'$	0.149	NS	0.123	NS	0.097	NS
W'	0.086	NS	0.071	NS	0.056	NS
$S \times W'$	0.122	NS	0.100	NS	0.079	NS
$M' \times W'$	0.149	NS	0.123	NS	0.097	NS
$S \times M' \times W'$	0.211	NS	0.174	NS	0.137	NS
CV %	16.94		16.77		15.86	