

RESPONSE OF WHITE MUSTARD (*SINAPIS ALBA* L) TO SPACING UNDER RAINFED CONDITIONS

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ABSTRACT

Growth and development of individual plants is modified with space available to plants. However, many crop species having tillering or branching mechanisms allow similar levels of yield and dry matter production per unit area from a range of planting densities. Response of white mustard (*Sinapis alba* L) to spacing was studied through field experiment conducted at PMAS-Arid Agriculture University, Research Farm, Chakwal Road, Rawalpindi during Rabi 2008-09. Nine plant to plant spacings (5, 7.5, 10, 12.5, 15, 17.5, 20, 22.5 and 25 cm) were laid out in randomized complete block design, when rows were 20 cm spaced. The experiment had three replications in net plot size of 2 x 6m. Plant spacing significantly affected all plant characteristics: plant height, branches, pods per plant, seeds per pod, thousand seed weight and seed yield. Although, no consistent pattern of increase or decrease of any parameter was exhibited by plants due to spacing, however, plant height showed linear relationship with spacing while inverse relationship was observed for seed yield. Plants spaced at 15 cm depicted the highest values for seed yield and related parameters. Thus, it may be concluded that white mustard (*Sinapis alba* L) should be grown at 15 cm spacing when rows are 20 cm spaced with projected plant population of over three hundred thousand per hectare to have profitable yield.

Key words: White mustard, plant spacing, row spacing, compensatory mechanism.

INTRODUCTION

In Pakistan, farm production is dominated by major crops in irrigated as well as rainfed areas, whereas, oilseeds find relatively low priority in our farming system. This situation led to acute shortage of edible oil and compelled to import edible oil and oilseed annually worth billion of rupees. Last year, 1.326 million tons edible oil worth Rs. 97 billion was imported (Govt. of Pakistan, 2011). The ever increasing demand of edible oil, has attained critical importance to the economy of Pakistan. Small and fluctuating domestic production base and every increasing import have forced policy makers to look for alternate sources of edible oil and oilseed production. Horizontal expansion of area under oilseeds has little chances as major focus of farmers and Govt. is on staple food security in irrigated and rainfed areas. However, traditional cropping pattern of Pothwar region has left some room for expansion of area under oilseed crops. Farmers of Pothwar leave half of their land fallow after harvesting of summer crops due to non-availability of moisture during months of October/November. However, low water requiring crops such as white mustard having ability to germinate under low temperature may be grown.

White mustard (*Sinapis alba* L.) is an emerging oilseed crop belongs to Brassicaceae family. White mustard is being considered as an alternative oilseed crop for dry and low rainfall climates. It possesses many beneficial characteristics such as pest resistance and a

short growing season (Bodnaryk and Lamb, 1991). In cold climates, white mustard (*Sinapis alba* L.) is a spring annual crop, thus may fit well in winter under local climatic conditions. Moreover, it may be well adapted to hot, dry growing conditions. Heat and drought tolerance of white mustard is superior compared to rapeseed or canola (*B. napus* or *B. rapa*). It has 55% higher seed yield than spring canola in regions those receive less than 12 inches of annual precipitation. White mustard plants have extensive root system that penetrates deep into the soil profile. More than 50% of all moisture up take is from below 5 feet in the soil profile, and hence can utilize nitrates those have leached down from other crops (Brown *et al.*, 2002). White mustard is highly competitive with weed species. In crop weed competition studies it has been shown that one wild oat plant was as competitive as four canola plants whereas one white mustard plant was more competitive than two wild oat plants (Duke, 1978).

Growth, development and final yield is mainly affected by the space available to plants, however, the precise and exact response will be species, and in some cases cultivar specific. The adjustment of plant population as per growing nature of plant is pre-requisite for higher yield of white mustard like other crops. Evenly distributed plants utilize land, light and other input resources uniformly and efficiently. Higher plant population per unit area beyond an optimum limit results in competition among the plants for natural resources, resulting weaker plant and may cause severe lodging. Plant density is one of the most important cultural

practices which ultimately affect seed yield, and other important agronomic attributes of any crop (Sangoi, 2000).

Light attenuation in row crops may be influenced by canopy architecture, which has to be defined in terms of the size, shape orientation of shoot components and row spacing (Awan *et al.*, 2011). Linear increase in grain yield has been reported with increase in plant density until other production factors become limiting (Norsworthy and Emerson, 2005). Similarly, Beg *et al.* (2007) observed that narrow row spacing (20 cm) coupled with less plant spacings resulted in higher plant populations of about 100000 plants /ha of sunflower provided an economical yield under rain-fed conditions. However, Leitch and Sahi (1999) reported that low-density populations produced more branches those carried fertile pods, thus prolonged the seed development phase in linseed. The presence of fewer pod-bearing branches should produce more synchronous pod and seed development and resulted in more uniform seed maturation and improved harvest ability.

White mustard is an exotic oilseed which has not been cultivated any where in the country, therefore, no systematic studies have ever been conducted on this crop. Being, a drought resistant, requiring small amount of water through out its life cycle, having shatter resistant pods are its unique characteristics those make it as a promise crop in future. Being a minor and exotic crop, it has not attracted many researchers to study its basic agronomy or plant responses to different techniques. Keeping in view the potential of white mustard over other oilseeds, the present study was planned to find out the optimum plant population and precise distribution for obtaining maximum plant growth and seed yield.

MATERIALS AND METHODS

Response of white mustard (*Sinapis alba* L) to plant spacing was studied through field experiment conducted at PMAS-Arid Agriculture University, Research Farm Chakwal Road, Rawalpindi during Rabi 2008-09 under rainfed conditions. Prior to sowing land was fallow during summer. Soil was ploughed with cultivator at the end of rainy season. At the time of last ploughing recommended dose (75-35-35 kg /ha) of NPK was incorporated in the soil. The sowing was done on pre-marked row spacing of 20 cm by hand drill on 22nd October, 2008. The trial was laid out in randomized complete block design with three replications. Each plot consisted of ten rows in net plot size of 2 x 6 m. The experiment consisted of nine plant to plant spacings (T₁=5 cm, T₂=7.5 cm, T₃=10 cm, T₄=12.5 cm, T₅=15 cm, T₆=17.5 cm, T₇=20 cm, T₈=22.5 cm and T₉=25 cm). Plant to plant spacing as per treatments was maintained by thinning at 3-4 leaves stage. Weeds were kept under control by hand weeding as and when needed.

At maturity, crop was harvested on 1st May, 2009. The central four rows from each plot were harvested to record seed yield, whereas, plant height, branches per plant, pods per plant were recorded from ten randomly selected plants from central rows. Hundred pods were randomly selected for recording seeds per pod. Three lots of thousand seeds were weighed for recording thousand seed weight, while seed yield per hectare was calculated from bulk sample. The data collected were subjected to analysis of variance technique and the treatments means were compared for significance by Duncan's New Multiple Range (DMR) test at 0.05% P (Duncan, 1955). Weather data was recorded during course of experimentation (Table 1).

RESULTS AND DISCUSSION

The final plant height reflects the growth behavior of a crop, besides genetic characteristics, soil nutrients status and environmental condition under which it is grown. Planting geometry of a crop plays a vital role in determining the height of the plants. The results presented in the table 2 depicted significant differences among treatments for plant height of white mustard. The maximum plant height (148.9 cm) was attained by the plants in T₅ which was statistically at par with T₆ and T₉ but differed significantly from rest of the treatments. The minimum plant height (132.4 cm) was exhibited by plants in T₁. A difference of 11% was visible between maximum and minimum values. The results are in agreement with the finding of Oad *et al.* (2001) who observed taller plants of brassica in the plots where crop was planted in rows of 60 cm apart. Linear relationship between spacing and plant height in present study (Fig. 1) is also in conformity to above findings. However, our results are contradictory to Hasanuzzaman and Karim (2007), they reported taller plants with increased plant density. Increase in height due to plant density may be a peculiar character of some species.

In brassica species, primary and secondary branches are of vital importance as these bear pods, those produce seed and affect yield. Statistically significant differences among spacing treatments were observed for primary branches per plant (Table 2). The maximum (16.72) primary branches per plant were observed on plants in T₆ which was statistically different from T₁, T₂ and T₇ while statistically similar with rest of treatments. The minimum (11.19) primary branches were recorded in T₁. The variability among treatments for primary branches may be due to availability of moisture and nutrients. Closely spaced plants might have faced competition for resources. Angadi *et al.* (2003) observed few branches per plant grown at highest densities. Thus, our findings are in line with them. The maximum (45.89) secondary branches per plant were produced by plants in T₉ which was statistically at par with T₆ but differed

significantly from rest of the treatments. The minimum (24.07) secondary branches were observed from plants in T₂. A difference of 45% was recorded between maximum and minimum values. Availability of space and nutrients would have encouraged side branches, thus, plants in widest spacing produced maximum branches. The results of present study are in agreement with Sharief and Keshta (2002), they recorded decreased number of secondary branches in brassica when plant density was increased from 8.3 to 16.6 m⁻².

The number of seeds per pod contributes materially towards the final seed yield. The number of seeds per pod differed significantly among different treatments (Table 2). The maximum (4.933) number of seeds per pod was observed in T₅ which was statistically at par with the T₇, T₈ and T₉ but differed from rest of the treatments. The minimum number of seeds per pod (3.83) was observed in T₄. Overall plant growth, development and final stature would have influenced total seed setting. Ozer (2003) observed consistent increase in the number of seeds per pod with increase in row spacing in rapeseed. Though, in our study increase in seeds per pod was not consistent yet widely spaced plants produced pods with greater number of seeds per pod. Thus, results are in conformity with above findings. Similarly, Hasanuzzaman *et al.* (2008) stated that the number of seeds per pod significantly decreased with the increase of population density in *Brassica campestris* L.

The weight of individual seed expresses the magnitude of seed development which is an important yield determinant and plays a decisive role in showing off the yield potential of a crop. Plant spacing had significant effect on TSW (Table 2). The maximum TSW (5.020 g) was observed in T₉, while, minimum (4.743 g) attained by T₁. The maximum TSW recorded from plants at widest spacing may be result of active photosynthetic machinery for longer period of time as plants did not face any competition for moisture or nutrients. The results are

in line with those of Hasanuzzaman and Karim (2007) those reported higher thousand seed weight at wider plant spacing.

Final seed yield of a crop is the expression of combined effects of various yield components. Plant spacing had significant effect on seed yield (Table 2). The maximum seed yield (2046 kg/ ha) was recorded from T₅ which was statistically similar with T₂ and T₃ but differed significantly from rest of the treatments, while, the minimum seed yield (1428 kg/ ha) was exhibited by T₉. Higher mean yield of *Sinapis alba* than national average yield (1500 kg/ha) of other brassicaceae family members may be result of well distributed rains throughout growing season (Table 1) and better potential of this particular crop under rainfed conditions. In general, there was no consistent response of spacing on seed yield, however, an inverse relationship between spacing and seed yield has been exhibited in our study (Fig. 2). Similar, trend has been observed in other crops, pearl millet (Mass *et al.*, 2007), sunflower (Al-Thabet, 2006) which seems to be logical as widely spaced plants

Table 1. Total rainfall mean temperature during crop growth cycle.

Month	Rainfall (mm)	Mean Min. Temp. (°C)	Mean Max. Temp. (°C)	Mean Temp. (°C)
October	23.0	16.3	30.8	23.55
November	1.0	8.8	26.5	17.65
December	57.0	6.8	21.0	13.9
January	68.0	6.0	18.6	12.3
February	34.0	7.6	20.4	14.0
March	28.0	11.8	26.2	19.0
April	72.5	12.3	31.3	21.8

Table 2. White mustard plant attributes in response to plant spacing.

Treatments	Plant height (cm)	Primary branches/plant	Secondary branches / plant	Pods / plant	Seeds / pod	TSW (g)	Seed Yield (Kg / ha)
T1 (5 cm)	132.4 d	11.95cd	24.62 f	1063 d	4.167 bcd	4.743 abc	1766 bc
T2 (7.5 cm)	135.0 d	11.19 d	24.07 f	1014 d	4.267 bc	4.883 ab	1902 ab
T3 (10 cm)	136.8 cd	14.15abcd	31.39 de	12.13 cd	4.233 bc	4.930 ab	1982 a
T4 (12.5 cm)	136.6 cd	14.75abc	29.44 ef	1553 bc	3.833 d	4.693 bc	1812 bc
T5 (15 cm)	148.9 a	16.13abc	38.68 bc	1747 ab	4.933 a	4.963 ab	2046 a
T6 (17.5 cm)	145.1 abc	16.72a	42.85 ab	1715 ab	4.033 bcd	4.937 ab	1595 d
T7 (20 cm)	138.3 bcd	12.67bcd	36.47 cd	1718 ab	4.367 ab	4.493 c	1704 cd
T8 (22.5 cm)	140.0 bcd	13.68abcd	37.30 bcd	1767 ab	4.333 ab	4.683 bc	1569 de
T9 (25 cm)	146.4 ab	15.78ab	45.89 a	2002 a	4.667 a	5.020 a	1428 e

Any two means in a column not sharing a letter differ significantly at P> 0.05.

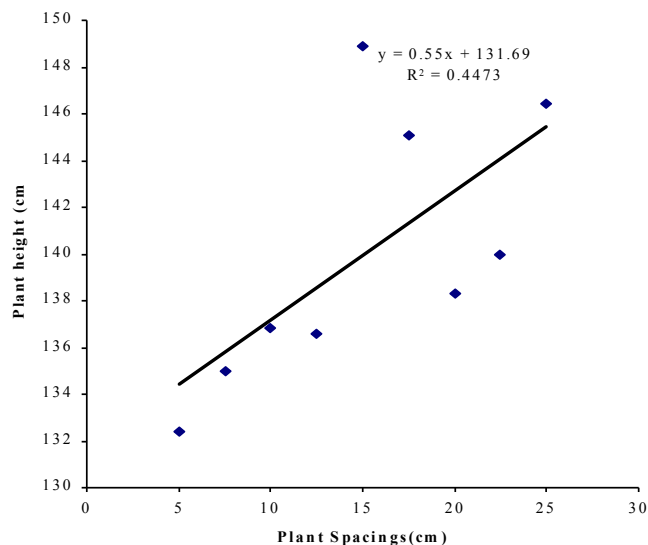


Fig. 1. Relationship between plant spacing (cm) and plant height (cm).

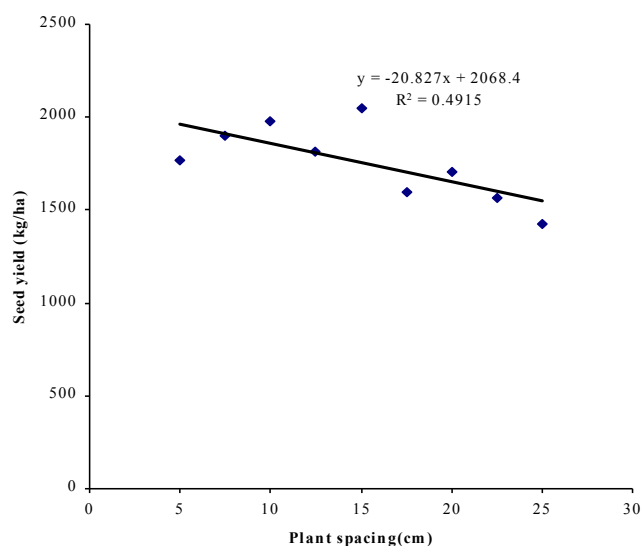


Fig. 2. Relationship between plant spacing (cm) and seed yield (kg/ha).

could compensate loss of yield up to some extent by producing more branches and healthier seeds, yet a reasonable number of plants per unit area is basic requirement to have good yield. There has not been any study conducted on this aspect or basic agronomy of *Sinapis alba*, thus, it may be concluded that *Sinapis alba* should be planted in 20 cm rows with 15 cm spacing between plants which will give approximate plant population of over three hundred thousands to have profitable seed yield. However, soil and environment related factors have to be taken into consideration for decision of plant population per unit area.

REFERENCES

- Al-Thabet, S. S. (2006). Effect of Plant Spacing and Nitrogen Levels on Growth and Yield of Sunflower (*Helianthus Annus* L.). J. King Saud Univ., 1:1-11
- Angadi, S. V., H. W. Cutforth, B. G. McConkey and Y. Gan (2003). Yield adjustment by canola grown at different plant populations under semiarid conditions. *Crop Sci.*, 43:1358-1366.
- Awan, T. H., R. I. Ali, Z. Manzoor, M. Ahmad and M. Akhtar (2011). Effect of different nitrogen levels and row spacing on the performance of newly evolved medium grain rice variety, KSK-133. *J. Anim. Plant Sci.*, 21(2):231-234.
- Beg, A., S. S. Pourdad and S. Alipour (2007). Row and plant spacing effects on agronomic performance of sunflower in warm and semi cold areas of Iran. *Helia*, 30(47): 99-104.
- Bodnaryk, R. P. and R. J. Lamb (1991). Mechanisms of resistance to the flea beetle *Phyllotreta cruciferae* Goeze in mustard seedlings *Sinapis alba* L. *Can. J. Plant Sci.* 71:13-20.
- Brown, J., J. B. Davis and A. Esser (2002). Pacific Northwest Condiment Yellow Mustard (*Sinapis alba* L.) Grower Guide, *University of Idaho Moscow, Idaho*, p9
- Duke, J. A. (1978). The quest for tolerant germplasm. In ASA Special Symposium 32, Crop tolerance to suboptimal land conditions. Am. Soc. Agron. Madison, WI. p. 1-61.
- Duncan, D. B. (1955). Multiple range and multiple F test. *Biometrics*, 11: 1-42.
- Govt. of Pakistan. (2011). Economic survey of Pakistan. Ministry of Food and Agriculture, Islamabad, Pakistan. pp.21.
- Hasanuzzaman, M. and M. F. Karim. (2007). Performance of Rapeseed (*Brassica campestris* L.) CV. SAU sarisha-1 under different row spacings and irrigation levels. *Res. J. Agri. & Bio. Sci.*, 3(6): 960-965.
- Hasanuzzaman, M., M. F. Karim and M. J. Ullah (2008). Growth dynamics of rapeseed (*Brassica campestris* L.) CV. SAU sarisha-1 as influenced by irrigation levels and row spacings. *Aust. J. Basic & Appl. Sci.*, 2(4): 794-799.
- Leitch, M. H. and F. Sahi (1999). The effect of plant spacing on growth and development in linseed. *Ann. App. Biol.* 135:529-534.
- Maas, A. L., W. W. Hanna and B. G. Mullinix (2007). Planting date and row spacing affects grain yield and height of pearl millet Tifgrain 102 in the Southeastern coastal plain of the United States. *Journal of SAT Agricultural Research* 5(1):1-4

- Norsworthy, J. K. and R. S. Emerson (2005). Effect of row spacing and soybean genotype on main stem and branch yield. *Agron. J.*, 97: 919-923.
- Oad, F. C., B. K. Solangi, M. A. Samo, A. A. Lakho, Z. U. Hassan and N. L. Oad. (2001). Growth, yield and relationship of Rapeseed (*Brassica napus* L.) under different row spacing. *Int. J. Agri. & Bio.*, 3(4): 475-476.
- Ozer, H. (2003). The effect of plant population densities on growth, yield and yield components of two spring rapeseed cultivars. *Plant Soil Environ.*, 4 (9): 422-426.
- Sangoi, L. 2000. Understanding plant density effects on maize growth and development: an important issue to maximize grain yield. *Ciênc. Rural* 31(1): 159-168.
- Sharief, A. E. and M. M. Keshta (2002) Influence of sowing dates and plant density on growth and yield of canola (*Brassica napus* L.) under salt affected soils in Egypt. *Sci. J. King Faisal Univ.*, 3:65-68.