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SPECTRAL REMOTE SENSING FOR THE CONTROL OF HARDY BROADLEAF WEED IN WHEAT (*TRITICUM AESTIVUM* L.)

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Key words: Broadleaf weed, *Malva neglecta*, Remote sensing, Wheat, Weed density

Abstract

A field experiment was conducted to determine the reflectance characteristics of *Malva neglecta* in wheat. The treatments consist of different weed densities of *Malva neglecta* i.e. 4, 8, 12, 16, 20, 24 plants/m^2 and alone *Malva neglecta* and wheat. There was reduction in yield attributes of wheat as the weed densities of *M. neglecta* increased from 4 to 24 plants/m^2. Highest grain yield of wheat was recorded in wheat alone and lowest grain yield was recorded in 24 plants of *M. neglecta*/m^2 in wheat which indicated that higher weed density supressed the growth and yield of wheat. Radiance ratio and NDVI values recorded were highest in wheat alone and lowest in *M. neglecta.* Wheat sown alone can be distinguished from alone *M. neglecta* at 30 DAS and remain distinguished up to 120 DAS. The different levels of weed densities can be discriminated amongst themselves from 60 DAS onwards.

Introduction

Wheat is an important cereal crop worldwide and in India it is the second most important staple food after rice. Its production is directly affected by large number of factors and weed infestation is one of the major factors limiting crop productivity. Effective weed management is a pre-requisite for realizing full genetic yield potential of the crop and sustaining food grain production to feed ever-increasing population and ensuring food security of the country and world. Many grasses and broadleaf weeds infests the wheat crop severely which results in drastic reduction in grain yield. With the sole use of grass killer herbicides, the infestation of broadleaf weeds is increasing at an alarming rate day by day (Chhokar and Malik 2002). Nowadays the infestation of *Malva neglecta* in wheat poses a serious threat and compete with the crop for water, sunlight, space and minerals (Pinter *et al.* 2003, Slaughter *et al.* 2008). Recently, the problem of *Malva* in wheat is increasing under no till situations. *M. neglecta* belonging to Malvaceae family, poses severe competition to wheat crop due to its more spreading type nature. Its single plant bear a large number of small button like fruits which helped its spread at an alarming rate. Its infestation in many fields is so severe that if remained unchecked it can grow above the crop canopy and completely check the growth of wheat crop. During 1997 and 1998, it was intercepted and identified in wheat grain consignments imported through 10 major parts of India (Singh 2001).

Detection of weeds has become prime importance for its selective management. If problematic weeds are identified through spectral measurements, then these weeds can be controlled at the right time by using appropriate weed control measures. This will further help in precise application of herbicide. Need based application of herbicides may have economical and environmental benefits as site-specific weed management helps in reducing the herbicide use by 11 - 90% without affecting crop yield (Gerhards and Christensen 2003). Reducing the quantity of herbicide applied significantly (Weis *et al.* 2008) site-specific weed control and management could benefit the farmers in economic terms as well as the environment, without diminishing weed

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control efficacy (Pinter *et al.* 2003, Slaughter *et al.* 2008). Over the past decade, a number of crop yield forecasting models by using remote sensing data have been developed (Idso *et al*. 1980, Dubey *et al.* 1994, Datta *et al.* 1995, Kaluburme *et al.* 1998, Urmil *et al.* 2003). *Isocoma coronopifolia* and *Isocoma drummondii* weeds can be separated from other species of plant and soil at flowering stage (Everitt *et al.* 1992) and best discrimination for *Ulex europaeus* (scrub weed) occurs during flowering period (Shepherd and Lee 2007). There are numerous indices, like NDVI which has been used to evaluate different plant growth parameters (Solari *et al.* 2008). Keeping in view the importance of remote sensing in site specific weed management, the objective of this study was to apply remote sensing for the detection of important and troublesome broadleaf weed *M. neglecta* in wheat crop by studying the spectral characteristics of *M. neglecta* and wheat and to find out the optimum time span for distinguishing *M. neglecta* from wheat crop, based on their relative spectral reflectance characteristics.

Materials and Methods

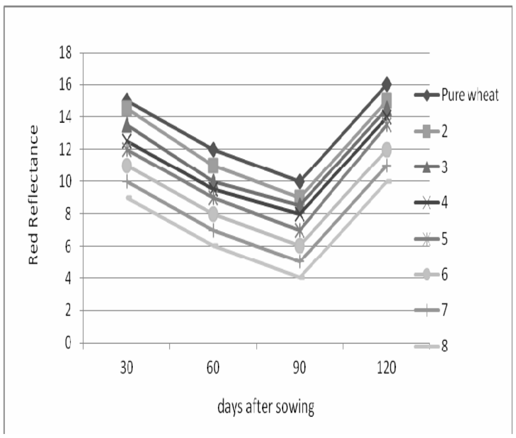
Field experiments were conducted at Research Farm, Punjab Agricultural University, Ludhiana (30°56’N latitude, 75°52’E longitude and 247 m altitude) during *rabi* season 2012-13 and 2013-14. The site is located in Trans-Gangetic agro-climatic zone and represents the Indo-Gangetic alluvial plains (30°56’N latitude, 75°52’E longitude and at an altitude of 247 m mean sea level). The soil was loamy sand, normal in reaction (pH 7.3) and electrical conductivity (0.15 dS/m), low in organic carbon (0.39%) and available nitrogen (225.2 kg/ha) and medium in available phosphorus (17.1 1kg/ha) and potassium (202.48 kg/ha).The experiment consists of different density levels of *Malva neglecta* i.e. 4, 8, 12, 16, 20, 24 plants/m^2 and sole *Malva neglecta* and wheat. The experiment was laid out in RCBD with four replications. The wheat cv. PBW 550 was sown on 12th November, 2012 and 11th November in 2013 using seed rate of 112.5 kg/ha. The recommended doses of fertilizers were applied (125 kg N/ha, 50 kg P_2O_5/ha and 30 kg K_2O/ha). The sources of NPK used was urea, DAP and muriate of potash, respectively. Half of the recommended dose of N and whole of phosphorus and potassium were applied at the time of sowing and remaining half dose of N was applied as top dressing at the time of first irrigation. The field was seeded with *Malva neglecta* seed according to the requirement of different weed density levels at the time of wheat sowing. The weed density was maintained with respect to the treatment. No weed seed was seeded in sole wheat stand and complete weed free situation was maintained throughout the season. Gap filling and thinning was done to maintain proper per hectare weed density.

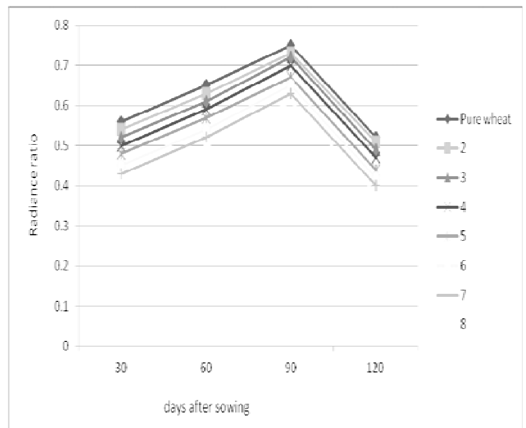
Spectral reflectance was recorded in two wave bands i.e. red (625 - 689 nm) and infrared (760 - 897 nm) at monthly intervals till harvest with the help of hand held ground truth spectro-radiometer. Pure white films are good reflectors of light so value of reflectance from a white plane were also recorded. With respect to these reflectance values per cent reflectance by crop in the red band (625 - 689 nm) of spectrum was calculated at different growth stages of the crop as like radiance ratio (RR) = Infrared reflectance (IR)/Red Reflectance (R).

Normalized difference vegetation index (NDVI) were calculated as from Red and Infrared band reflectance by the following formulae: NDVI = (IR - R)/(IR + R).

Results and Discussion

During the initial phase of crop growth, there was increase in radiance ratio (Fig. 1). This might be due to increase in dry matter and values increased till the crop attains maximum canopy cover (90 DAS) and later it decreased with the senescence of the crop. The highest RR value was obtained at 90 DAS in wheat sown alone and decrease in value was recorded with the increase in density of *Malva neglecta*. This could be more scattering of light in the intercellular space and less reflectance of NIR band relative to the red band which leads to decrease in radiance ratio at 90 DAS in *Malva neglecta*. The differences in RR values between sole wheat and sole weed were mainly due to dark green colour of wheat having more LAI and biomass of wheat crop as compared to sole *Malva neglecta*. The data on radiance ratio showed that the density levels of 4 to 24 plants of *Malva neglecta*/m^2 can be distinguished from each other in their radiance ratio at 30-90 DAS stage of the crop. Data in Fig. 2 represent that there was decrease in red reflectance in all

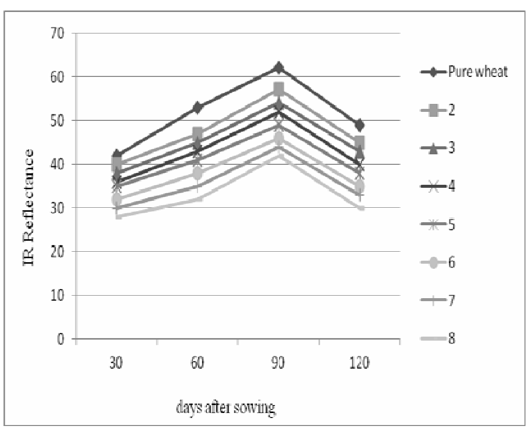


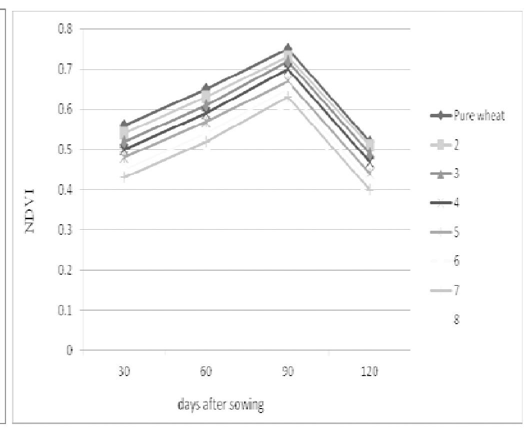


2, 3, 4, 5, 6,7 are 4, 8, 12, 16, 20 and 24 *Malva neglecta*/m^2 and 8 is Pure *M. neglecta*, respectively.

Fig. 1. Red reflectance of wheat crop under different population levels of *M. neglecta.*

Fig. 2. Radiance ratio of wheat crop under different population levels of *M. neglecta.*





2, 3, 4, 5, 6, 7 are 4, 8, 12, 16, 20 and 24 *Malva neglecta*/m^2 and 8 is Pure *M neglecta*, respectively.

Fig. 3. IR reflectance of wheat under different population levels of *M. neglecta.*

Fig. 4. NDVI of wheat crop under different population levels of *M. neglecta.*

the treatments irrespective of wheat and weed density from 30 to 90 DAS and after 90 days of sowing, a sharp increase in red reflectance was recorded till the maturity of the crop. The reason could be due to increased chlorophyll index at 30 DAS as red reflectance was reduced by chlorophyll absorption and sharp increase at 90 DAS. This might be due to less absorption of red

Table 1. Growth parameters of wheat affected under different *Malva neglecta* densities.

Treatments	Plant height (cm)	LAI	DMA (q/ha)	Number of tillers/m^2			PAR inter-ception (%)	Chl. index	Effec-tive tillers/ m^2	Ear length (cm)	Grains per ear (No.)	1000-grain wt (gm)	Grain yield (q/ha)
	At harvest			60 DAS	90 DAS	120 DAS	90 DAS						
Wheat (alone)	96.98	3.70	122.94	592.17	604.73	596.61	77.43	48.23	589.95	12.13	44.29	42.18	57.9
4 *Malva neglecta*/m^2	95.98	3.54	112.88	582.50	592.00	581.50	77.75	46.70	570.00	11.40	42.76	40.60	53.9
8 *M. neglecta*/m^2	95.27	1.72	102.97	572.35	582.57	567.54	77.92	46.00	560.33	10.38	41.53	39.57	49.5
12 *M. neglecta*/m^2	94.37	3.31	95.80	560.43	567.75	558.60	78.05	44.60	550.49	9.54	40.64	38.92	45.5
16 *M. neglecta* /m^2	94.10	3.14	89.12	547.45	558.04	549.80	78.88	43.93	541.48	9.12	39.12	37.32	40.1
20 *M. neglecta* /m^2	93.27	3.00	84.03	540.70	551.83	541.53	79.18	42.47	532.90	8.41	38.49	36.10	34.5
24 *M. neglecta* /m^2	91.04	2.90	79.97	535.43	544.0	534.6	79.35	41.67	524.57	7.69	37.28	34.35	29.9
M. neglecta (alone)	0	0	0	0	0	0	0	0	0	0	0	0	0
C.D (p = 0.05)	0.67	0.15	4.57	7.33	3.05	3.36	0.29	0.94	6.65	0.61	1.00	0.97	2.3

light by the crop canopy as the crop approaches towards maturity. Sole *M. neglecta* recorded minimum red reflectance and maximum RR in sole wheat as compared to all other treatments. However, reverse trend was recorded in IR reflectance values (Fig. 3). IR increased in all the treatments with the advancement of crop growth. In all the treatments, IR reflectance values showed decline sharply at 90 DAS. As the crop approaches towards maturity, more scattering of infra-red light in the mesophyll cells of the leaves took place which ultimately decreased the reflectance. Increased reflectance from weed infested areas was most likely due to increased biomass and canopy cover. Similar results were reported by (Chang *et al.* 2004).

Normalized difference vegetation index (NDVI) is the most widely used index for assessing population. NDVI has been related to nitrogen status, chlorophyll content, green leaf biomass and grain yield (Solari *et al.* 2008). The values of NDVI for variable density of *M. neglecta* increased with the increase in the advancement of crop growth and reached maximum at 90 DAS and later on it decreased sharply (Fig. 4). The decrease might be due to decrease in absorption of light in red region owing to cell degeneration and decrease in LAI. Among all the treatments, sole wheat crop recorded the highest NDVI values. The different density levels of *M. neglecta* can be easily distinguished from sole wheat crop at 30 DAS. The highest RR and NDVI values were recorded under sole wheat crop and lowest under *M. neglecta* density.. It was observed that by using RR and NDVI, pure wheat crop can be distinguished from pure mixed populations of *M. neglecta* at 30 DAS and different weed densities can be discriminated amongst themselves from 60 DAS onwards. Leaf area index and biomass were highly correlated with vegetation indices than crop height and canopy cover (Thenkabail *et al.* 2000).

Table 2. Growth characteristics of *Malva neglecta* under their varying density levels.

Treatments	Plant ht. (cm)	LAI				Dry matter accumulation (q/ha)				
	90 DAS	30 DAS	60 DAS	90 DAS	At maturity	30 DAS	60 DAS	90 DAS	120 DAS	At maturity
Wheat (alone)	0	0	0	0	0	0	0	0	0	0
4 *Malva neglecta*/ m^2	46.10	0.91	1.89	2.36	2.81	3.40	7.33	7.61	8.57	9.4
8 *M. neglecta*/m^2	48.21	0.95	2.00	2.45	2.93	3.88	7.91	8.13	8.92	9.59
12 *M. neglecta*/m^2	50.35	0.98	2.19	2.57	3.13	4.36	8.30	8.91	9.46	9.96
16 *M. neglecta/*m^2	53.48	1.07	2.28	2.79	3.22	5.37	9.27	9.61	10.25	10.69
20 *M. neglecta*/m^2	55.78	1.29	2.49	2.90	3.37	6.37	10.22	10.92	11.43	11.84
24 *M. neglecta*/m^2	59.50	1.27	2.68	3.04	3.46	7.64	11.37	11.94	12.57	12.88
M. neglecta (alone)	62.37	1.47	2.88	3.24	3.65	8.69	12.84	13.04	13.64	13.89
C.D. (p = 0.05)	1.91	0.12	0.14	0.33	0.17	0.30	0.46	0.43	0.44	0.74

The perusal of data in Table 1 indicated that plant height recorded was at par having 4 plants of *M. neglecta*/m^2 with sole wheat (Table 1). Similar trend was also recorded in LAI (Table 1). Significantly more dry matter was accumulated in sole wheat crop as compared to 4 to 24 plants of *M. neglecta*/m^2 in wheat. The presence of 4 plants of *M. neglecta*/m^2 in wheat resulted in reduction of dry matter to the tune of 8.18 percent (Table 1). The perusal of data recorded showed that more the density of *M. neglecta* per square metre, more was the interception of PAR. However, reverse trend was recorded in chlorophyll index. As the density of *M. neglecta* increased in wheat, there was significant reduction in tillers per square metre as compared to sole wheat crop. Weeds compete with the crop for all the growth factors and as a result significant reduction in the tiller growth was observed. The perusal of data in Table 1 showed that sole wheat crop recorded significantly more effective tillers per square metre, ear length, grains per ear, 1000-grain weight, grain and straw yield as compared to different weed density treatments. With the increase in weed density per unit area, a significant decrease in the ear length of the crop was recorded. Minimum ear length (7.69 cm) was recorded in 24 plants of *M. neglecta* per square metre crop and presence of 24 plants/m^2 caused 36.6 per cent reduction in ear length as compared to wheat sown alone. With increase in weed density of *M. neglecta* from 4 to 24 plants/m^2, there was a reduction in number of grains per ear up to the tune of 3.5 to 15.8 per cent as compared to alone wheat (Table 1). With the increase in weed density per unit area, there was decrease in 1000-grain weight of the crop (Table 1). The data on the grain yield recorded that with the increase in infestation of weed species from 4 to 24 plants/m^2, a decrease in grain yield of wheat was recorded. Significantly highest grain yield (57.9 q/ha) was observed in wheat alone, which was significantly more than all the treatments. *M. neglecta* caused 7 - 48% reduction in grain yield of crop (with plant density of 4 to 24 plants/m^2). The reduction in grain yield due to *M. neglecta* is due to weed competition with the crop for available light, nutrients, space, moisture etc. Wheat yield penalty was recorded mainly due to weed competition which ultimately reflected of decrease in effective tillers. The data recorded in Table 3 showed that as the number of weed plants per unit area increased, plant height, LAI and dry matter accumulation by the weed was also increased. These growth parameters of weed competed well with the crop for all the resources at different growth stages so decrease in growth and yield attributes was recorded in the wheat crop.

It is concluded that wheat sown alone can be easily distinguished or discriminated from *M. neglecta* at 30 DAS. NDVI and radiance ratio (RR) are the most reliable remote sensing indices to distinguish different density levels of weed specie like *M. neglecta* having 8, 12, 16, 20 and 24 plants/m^2 from the wheat crop alone, but at lower weed density *viz.*, 4 plants/m^2 is little bit difficult to distinguish from wheat alone at 30 DAS. So the use of remote sensing technology can help in distinguishing different weed species and their infestation in field crops. Hence there is a great potential for early decision making for particular weed species.

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