Effect of Agrochemicals on Growth, Yield and Quality of *aestivum* and *durum* Wheat Varieties Under Limited Irrigation Conditions

सिंचाई की सीमित परिस्थितियों के अर्न्तगत कृषि रसायनों का गेहूँ की *एस्टीवम* एवं *ड्यूरम* किस्मों की वृद्धि, उपज एवं गुणवत्ता पर प्रभाव

Satidan Yadav

Thesis

Master of Science in Agriculture

(Agronomy)

2001

Department of Agronomy

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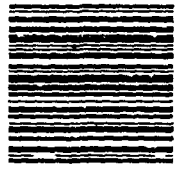
Udaipur



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Thesis
Submitted to the
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(***Agronomy***)

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ACRONYMS

@	-	At the rate of	ha^{-1}	-	per hectare
AICMIP	-	All India Coordinated Maize Improvement Project	hrs.	-	Hours
			HI	-	Harvest index
			IARI	-	Indian Agricultural Research Institute
AOAC	-	Association of Official Agricultural Chemist	i.e.	-	that is
%	-	Per cent	kg	-	Kilogram
°C	-	degree celsius	MSS	-	Mean sum of square
°E	-	degree East	M.P.	-	Madhya Pradesh
°N	-	degree North	m^{-1}	-	per metre
B:C	-	Benefit : cost ratio	m^{-2}	-	per square metre
cm	-	centimetre	mg	-	Milligram
cv.	-	Cultivar	mm	-	Millimetre
CCC	-	Cycocel	Max.	-	Maximum
CD	-	Critical difference	$Mg\ m^{-3}$	-	Mega gramme per cubic metre
CGR	-	Crop growth rate			
CU	-	Consumptive water use	Min.	-	Minimum
CV	-	Coefficient of variation	N	-	Nitrogen
CZ	-	Central Zone	NS	-	Non-significant
d.f.	-	degrees of freedom	NWPZ	-	North Western plain zone
$dS\ m^{-1}$	-	deci Simon per metre	PEP	-	Phosphoenol pyruvate
DAP	-	Diammonium phosphate	ppm	-	Parts per million
			P/P_2O_5	-	Phosphorus
DAS	-	Days after sowing	q/Q	-	Quintals
DM	-	Dry matter	r	-	Correlation coefficient
DMA	-	Dry matter accumulation	Rs	-	Rupees
			RGR	-	Relative growth rate
DWR	-	Directorate of Wheat Research	RH	-	Relative humidity
			SEm±	-	Standard error of mean
et al.	-	(et alibi) and elsewhere	TCA	-	Tri carboxylic acid
EC	-	Electrical conductivity	Temp.	-	Temperature
ET	-	Evapotranspiration	U.P.	-	Uttar Pradesh
Fig./FIG.	-	Figure	USWB	-	United States Weather Bureau
GWC	-	Ground water contribution			
			Var./var.	-	Variety
g	-	Gram	viz.	-	(videlicet) namely
			WUE	-	Water use efficiency

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1. INTRODUCTION

Since time immemorial, wheat is considered to be one of the most important cereal for mankind not only in quantitative terms but qualitative too. In India, wheat along with rice serves as life sustaining crops for more than 900 million population, thus considered to be backbone of the nation's food security system. Wheat is most staple crop of India and occupies second position both in terms of gross hectarage and production after rice.

The country has made a spectacular progress in elevating its productivity from 6.63 q ha^{-1} (1950-51) to 25.8 q ha^{-1} (1999-2000). At present, wheat is being cultivated over an area of 26.6 million hectares with production of 70.7 million tonnes (Fertilizer Statistics, 1999-2000). Among wheat growing states, Rajasthan is one of the leading states which occupies 10 per cent of national wheat hectarage and contributes about 9 per cent towards national wheat basket. The average productivity of Rajasthan is 24.8 q ha^{-1} (Fertilizer Statistics, 1999-2000) which is almost at par with national average. Though in Rajasthan, almost 90 per cent of wheat hectarage is irrigated but under the prevailing climatic conditions, the irrigation provided to the crop are sub-optimal (2-3 irrigations). There is fluctuation in the productivity of crop over the years in the state probably on account of irrigation constraints. In view of this situation, there is a need to enhance the productivity of the crop under irrigation constraints.

The evaluation of high yielding stable genotypes having good quality is considered pre-requisite for increasing the productivity of crop under limited irrigation conditions in any region, because water is a major limiting factor for crop production under such type of conditions. In this direction, attempts have been made to identify short duration and drought tolerant wheat varieties for cultivation under limited irrigation conditions. However, there

is need to broaden genetic base and replace old improved varieties with new ones. The recommendations of several varieties helps the farmers to choose best one and ensure adequate supply of improved variety seed. The choice of variety also depends on the onset of higher and impropitious air temperature, where differences in crop agronomy lead to differences in sowing dates. The number of effective tillers per unit area, average seed yield per ear and test weight are crucial parameters which determine the yield in wheat.

Regulation of plant growth by using agrochemicals at most appropriate time and concentration has created a vast scope for obtaining higher yields, as is evident from the work done by various researchers in the recent past. The use of agrochemicals does not increase the cost of production to any appreciable extent. Such chemicals have been found to maintain favourable internal plant water balance, thus avoiding temporary water stress and thereby increasing the crop yield considerably (Wunsche, 1970). Among the agrochemicals, cycocel (CCC) is known to play a vital role in physiological process of plants, thereby modifying the growth, yield and quality of the most crops. Cycocel retards the vegetative growth of plants and helps in conserving soil moisture (Devenda, 1996). It is being used on commercial scale for shortening height of winter wheat in several countries. It also improves protein content, protein yield and quality of winter wheat (Chrominski, 1972). Sulfhydryl compound thiourea is a new group of agrochemicals which helps to overcome environmental stress (Levitt, 1969). Sulfhydryl group has also been implicated in phloem transport of sucrose, the major photosynthetic metabolites in plants (Gaiquinta, 1976). Succinic acid is one of the member of Tri-Carboxylic Acid (TCA) cycle operated in plants for release of energy (Smith *et al.*, 1987). Succinic acid increases protein content in leaves at all stages of wheat crop (Kirillova, 1978).

Considering the above facts, the present experiment

entitled "Effect of Agrochemicals on Growth, Yield and Quality of *aestivum* and *durum* Wheat Varieties Under Limited Irrigation Conditions" was conducted during *rabi,* 2000-2001 with the following objectives :

(i) To study the effect of agrochemicals on growth, yield and quality of wheat varieties.

(ii) To select the best suited variety of wheat under limited irrigation conditions.

(iii) To study the effect of agrochemicals on water use efficiency of wheat varieties.

2. REVIEW OF LITERATURE

In the following pages, a brief review pertaining to research work done on the "Effect of Agrochemicals on Growth, Yield and Quality of *aestivum* and *durum* Wheat Varieties Under Limited Irrigation Conditions" is presented in this chapter. Since, the relevant literature on the aforesaid aspects on wheat is very meagre, particularly in the state of Rajasthan, related research findings involving barley and other field crops have also been incorporated wherever deemed necessary. Similarly, the studied varieties have not been extensively evaluated, findings for other varieties are given in succeeding paragraphs to elucidate marked variations in their performance.

2.1 EFFECT OF VARIETIES :

2.1.1 Growth Characters :

2.1.1.1 Plant height : Earlier investigations at IARI (New Delhi) revealed that among aestivums, Sonara-64 attained least height while it was highest under NP-718 (Singh *et al.,* 1970). Sharma and Dhillon (1993) noted significantly higher height of var. PBW-154 (83.5 cm) compared to 61.1cm height of var. PBW-222. It has been generally reported that the wheat varieties released in recent years did not vary in plant height on account of presence of dwarfing gene rht_2. Alike *aestivums, durums* did not show marked difference in height of plants in NWPZ (DWR, 1993). While in the year 1993-94, WH-896 attained highest height compared to PDW-233, PDW-215, PDW-34 (DWR, 1994). But in the year 1994-95, evaluated *durums* in NWPZ were at par in this respect (DWR, 1995). In CZ, non-significant variation in height of plants was observed between HI-8498 and HI-8381 (DWR, 1998). Sandhu *et al.* (1999) reported that among *aestivums*, height of PBW-175 was higher by 9.0cm over PBW-320 and PBW-359. In the year 1998-99, *durum* var. HI-8498 and Raj-1555 attained less height by

5 and 4cm, respectively compared to Lok-1 (DWR, 1999a). In CZ, mean over the locations indicated that plants of *durum* var. Raj-1555 were taller compared to mean height of 81 and 83cm observed in var. HI-8498 and Lok-1 (DWR, 2000a).

2.1.1.2 Phenological development : At Udaipur, recently released var. GW-173 attained heading and maturity earlier by 7 days compared to Lok-1 (DWR, 1993). Under normal sown irrigated conditions of NWPZ, *durums* did not exhibited variation in duration for phenological development (DWR, 1993). However, multilocational trials conducted in NWPZ revealed that var. WH-896 and PDW-215 attained heading at 104 days compared to 100 and 99 days under PDW-233 and PDW-34 but maturity of these ranged between 137-140 days (DWR, 1994). At Pantnagar, evaluation of 10 wheat varieties showed marked variation in phenological development. Among vatieties, UP-1183 required highest duration for heading and maturity while these were least for Sonalika (Tiwari and Singh, 1995). Like wise, at Udaipur var. Lok-1 and GW-173 attained various phenological stages earlier compared to GW-190 and Raj-3077 (Jat, 1995). The evaluation of *durums* in CZ failed to show any marked variation in phenological development (DWR, 1996). However, test entry HI-8498 attained heading earlier by 3 days over 72 days required by Raj-1555 but for maturity both the varieties did not differ (DWR, 1998). The zonal means for varietal performance indicated that *durums* required 100 and 145 days for heading and maturity in NPWZ, while these were 75 and 115 days in central zone (DWR, 1996). Under CZ, compared to *aestivums, durums* showed slight delay in heading and maturity (DWR, 2000b).

2.1.1.3 Dry matter accumulation : Significant variation in biomass accumulation by *aestivums* was observed by Ram and Bhardwaj (1983). Among tested varieties, Raj-821 produced higher dry matter

by 17.9 and 7.1 per cent over HD-2016 and Sonalika. At Pantnagar, UP-369 recorded maximum flag leaf area and dry matter over other varieties (Verma and Singh, 1988). At Udaipur, Lok-1 accumulated 13.1 per cent higher biomass over Raj-3077 (Buldak, 1994). Among four *aestivums*, Lok-1 recorded the highest dry matter at tillering, boot, milk and harvest stages of the crop over GW-173, Raj-3077 and GW-190 (Jat, 1995). At Durgapura (Raj.), among *durums*, WH-896 produced the highest biomass (87.1 q ha^{-1}), which was higher by 3.9 q ha^{-1} over PDW215 but found at par with PDW245 (DWR, 1996). At Udaipur (Raj.), among *aestivums*, GW-173 produced significantly higher number of tillers over Lok-1 and Raj-3077 but Raj-3077 recorded maximum biomass production over other varieties (Kuntal, 1997). At Hisar, under normal sown conditions, WH-896 accumulated 175 q biomass per ha which was higher by 25, 28, 16 and 14 per cent over PDW-215, HD-4633, PDW-238 and PDW-236, respectively (Madan and Kumar, 1998). Among three *aestivum* varieties, Lok-1 recorded significantly higher dry matter per unit area over Raj-3077 and GW-190 at pre-flowering and at harvest (Bairwa, 1999). Like wise, Kulhari (1999) reported that var. Raj-3077 accumulated significantly higher biomass in stem (at pre-flowering and harvest) as well as in leaves (at flowering) over the other test varieties whereas, dry weight of ears and whole plant (at harvest) was markedly improved under var. GW-173. Among two *durum* varieties namely Raj-1555 and HI-8498, var. HI-8498 acumulated significantly higher biomass over Raj-1555 by 6.2 and 21.6 per cent at 90 DAS and at harvest, respectively (Swami, 1999).

2.1.2 Yield Attributes :

2.1.2.1 Effective tillers : At IARI (New Delhi), among the three varieties studied, Moti produced higher number of total and effective tillers than Sonalika and NP-824 (Ready and Prasad, 1980). Malik (1981) recorded significantly higher tillers under var. HD-2009

over Raj-821. Rao and Bhardwaj (1981) reported significantly higher (114.9) effective tillers per metre row length under *aestivum* wheat variety HD-2160 compared to *durum* var. HD-4530. Similarly, at IARI, Kalyan Sona produced significantly higher tillers over HD-4519 and Raj-911 (Sharma and Bhardwaj, 1983). Singh and Dixit (1985) reported that wheat varieties Raj-1555 and WH-147 produced higher number of effective tillers per plant over rest of the test varieties. At Indore (M.P.), compared to WH-147, J-405 and Raj-1555, var. HD-2327 recorded higher effective tillers (Girothia *et al.*, 1987). While, Patra (1990) failed to record significant variation in effective tillers between wheat varieties. Singh and Verma (1990) observed higher effective tillers in Raj-1555 than WH-147 and HD-2236. At Lakhoti (U.P.), the highest ears m^{-2} were produced by HD-2329 (Singh and Singh, 1991). At Rajendranagar (Hyderabad), significantly higher effective tillers were produced by NI-5439 compared to HD-2189 (Pratibha *et al.*, 1992). At Udaipur (Raj.), Buldak (1994) noted the maximum number of tillers m^{-2} under Lok-1 compared to Raj-3077 and Sonalika. Among five varieties evaluated at Pusa (Bihar), HP-1102 produced least number of tillers among the other varieties namely UP-262, HP-1209, HUW-1234 and HUW-376 (Thakur *et al.*, 1995). At Jabalpur (M.P.), Lok-1 was found significantly superior to Sonalika in respect of effective tillers (Upadhyay and Tiwari, 1996). In CZ, Raj-1555, HI-8381 and HI-8498 did not vary in respect of tillering (DWR, 1997). At Udaipur (Raj.), Kuntal (1997) noted significantly higher effective tillers m^{-2} under GW-173 over Raj-3077 and Lok-1. In CZ, HI-8498 recorded marginal reduction by six tillers m^{-2} over 314 tillers m^{-2} produced by Raj-1555 (DWR, 1998). Patel *et al.* (1999) reported that ear m^{-1} row length were significantly higher in GW-173 compared to Mangla, Swati and Lok-1. At Udaipur, var. Lok-1 produced significantly higher effective tillers m^{-2} over GW-190 and Raj-3077 (Bairwa, 1999). But Kulhari (1999) reported significantly higher effective tillers (323 m^{-2}) under var. GW-173 compared to Raj-3077 (313

m^{-2}). Among ten wheat varieties evaluated at Almora, local cultivar produced significantly the highest number of effective tillers (446 m^{-2}) while among improved varieties CPAN-1976 recorded the highest number of effective tillers (387 m^{-2}) compared to other varieties (Pandey *et al.,* 2000). At Rewa (M.P.), DL-803-3, Raj-1555, WH-147 and DL-788-2 were observed at par in respect of tillers per plant (Mishra *et al.*, 2000). Sardana and Sharma (2000) recorded significantly higher effective tillers m^{-1} with var. PBW-373 compared to Raj-3765 and PBW-138.

2.1.2.2 Ear characteristics : Earlier investigations revealed that varieties markedly differed with respect to ear characteristics. At IARI (New Delhi), Raj-821 recorded significant improvement in grain weight per spike over var. HD-2016 and Sonalika (Ram and Bhardwaj, 1983). At Indore (M.P.), compared to WH-147, J-405 and Raj-1555, var. 2327 recorded higher ear length (Girothia *et al.,* 1987). Singh and Singh (1991) reported significant variation in yield attributes at Lakhoti (U.P.), wherein, the longest ears were produced by HD-1553 while var. HD-2285 recorded the highest number of grains per ear. At Rajendranagar (Hyderabad), var. HD-2189 recorded higher length of panicle together with more fertile spikelets per ear compared to other test varieties namely HD-2380, HD-4502 and NI-5439 (Pratibha *et al.,* 1992). At Powerkheda (M.P.), significant variation in ear characteristics was observed wherein the maximum ear length was recorded under HD-1553, while the highest spikelets per ear and grains per ear were produced by var. HI-1123 and Raj-1555, respectively (Jain *et al.*, 1992). Among ten varieties, UP-1182 recorded significantly higher grain weight per ear (Tewari and Singh, 1993). At Udaipur (Raj.), Buldak (1994) noted the highest number of grains per ear under Raj-3077 and the highest ear length was attained by var. Sonalika. Thakur *et al.* (1995) reported that HP-1102 produced least number of fertile spikelets, grains per ear among the other varieties viz., UP-262, HP-1209,

HW-234 and HUW-376. At Jabalpur (M.P.), Lok-1 was found significantly superior to Sonalika in respect of fertile spikelets, grains and grain weight per ear. However, Sonalika recorded significantly higher ear length (Upadhyay and Tewari, 1996). At Udaipur, Kuntal (1997) noted significantly higher number of grains per ear under Raj-3077 compared to Lok-1 and GW-173. Under CZ, among the *durum* varieties, Raj-1555 produced marginally higher grains (48 grains per ear) compared to 45 grains per ear in HI-8381 and HI-8498 (DWR, 1998). At Udaipur, var. HI-8498 produced significantly higher grains per ear (46 grains per ear) compared to 43 grains in Raj-1555 (Swami, 1999). At Gurdaspur (Punjab), varieties failed to show any significant variation in ear characteristics (Sardana and Sharma, 2000). But at Pantnagar (U.P.), var. Raj-3765 recorded significantly higher number of grains per ear compared to HD-2402, UP-2338, PBW-226, Raj-3077, UP-2121 and UP-2449 (Nainwal and Singh, 2000).

2.1.2.3 1000-grain weight : At Varanasi (U.P.), among 8 wheat varieties, S-308 recorded significantly higher test weight over rest of the varieties (Mishra *et al.,* 1980). While at Parbhani (Maharashtra), S-237 was found significantly superior over S-308, Sharbati Sonora and HI-747-19 in this respect (Upadhyay and Kuberkar 1980). At Hisar, Sonalika and WH-175 recorded significantly higher test weight compared to Kalyan Sona (Singh and Mohan, 1983). While at New Delhi var. Raj-821 recorded significantly higher test weight over HD-1016 and Sonalika (Ram and Bhardwaj, 1983). At Indore (M.P.), compared to WH-147, J-405 and HD-2327, var. Raj-1555 recorded the maximum 1000-grain weight (Girothia *et al.,* 1987). Kumpawat and Rathore (1989) recorded significantly higher test weight in var. Raj-821 over Sonalika, Kalyan Sona and HD-2236. At Rewa (M.P.), test weight of var. Lok-1 was found to be the main yield contributing factor (Khare *et al.,* 1989). At Keonjhar (Orissa), grains produced by Sonalika were heavier compared to

Sagarika (Patra, 1990). At Udaipur, Buldak (1994) noted the highest 1000-grain weight under Lok-1 compared to Raj-3077 and Sonalika. While, Jat (1995) recorded marginal improvement in test weight under Lok-1 compared to GW-173. At Kanpur, var. Sonalika exhibited superiority in test weight over HUW-234 and K-8020 (Singh *et al.*, 1997). Like wise, at Bhilwara, Gupta *et al.* (1998) recorded significantly higher (46.8g) test weight under Lok-1 compared to *Kalyan Sona, WH-147, C-306, D-134 and Sonalika. In CZ, grains* of newly released var. HI8498 had highest test weight (51.0g) while it ranged from 44.0g in HI-8381 to 45.0g in Raj-1555 (DWR, 1998). Patel *et al.* (1999) recorded significantly highest test weight under var. Lok-1 compared to Swati, Mangla and GW-173. While, at Udaipur, var. GW-173 recorded highest 1000-grain weight over Raj-3077 (Kulhari, 1999). In an another experiment at the same location, Bairwa (1999) recorded significantly higher test weight of var. Lok-1 compared to GW-190 and Raj-3077. In a study, the 1000-grain weight of all the Indian varieties (45.7g) was found higher than European varieties (40.5g) [Chowdhary and Sharma, 2000).

2.1.3 Yield :

2.1.3.1 Grain yield : Marked variation in yield potential of 20 wheat varieties was recorded at Pune (Maharashtra) by Sable (1983a). Further, it was reported that HI-784, DWR-39 and DWR-16 produced significantly higher yield over rest of the varieties. The same author in another trial recorded higher grain yield with var. HD-2189 and HW-135 over check var. Sonalika (Sable, 1983b). At New Delhi, Raj-821 out yielded HD-2016 and Sonalika by producing higher yield by 4.4 and 2.7 q ha^{-1}, respectively (Ram and Bhardwaj, 1983). At Hisar, compared to long duration var. Kalyan Sona, short duration var. Sonalika and WH-175 produced higher yield by 6.7 and 5.0 q ha^{-1}, respectively (Singh and Mohan, 1983). At IARI (New Delhi), among eight *aestivum* and *durum* varieties,

durum var. DWL-5023 recorded the highest (45.0 q ha^{-1}) grain yield (Lal, 10854). At Sabour (Bihar), Sonalika out yielded by 2.7 and 6.1 q ha^{-1} over UP-115 and HP-1209, respectively (Roy and Singh, 1990). Among 4 varieties, HD-2189 recorded significantly higher grain yield by 28.6 and 30.1 per cent over HD-2380 and HD-4502, respectively (Pratibha *et al.,* 1992). At Ghagharaghat (U.P.), HD-2285 produced higher yield over HD-1553 and HD-1209 (Singh and Singh, 1993). In comparison to Sonalika and Raj-3077, Lok-1 produced higher grain yield by 11.06 and 10.53 per cent respectively (Buldak, 1994). At Udaipur, GW-173 and Raj-3077 exhibited higher potential over Lok-1 and WH-147 (DWR, 1994). At Pusa (Bihar), HP-1102 was found higher yielder over rest of the test varieties (Thakur *et al.,* 1995). Singh and Prasad (1996) recorded higher yield under var. K-8020 over HD-2402, HD-2285 and HD-2307 at Kanpur. While, at Jabalpur (M.P.), Lok-1 was found superior yielder over Sonalika (Upadhyay and Tiwari, 1996). In CZ, *durum* var. HI-8498, HI-8381 and Raj-1555 were found at par in yield potential (DWR, 1997). But during 1998-99, HI-8498 out yielded Raj-1555 and HI-8381 by producing 5.9 q higher yield ha^{-1} (DWR, 1999a). Among four varieties, GW-173 recorded significantly higher yield by 3.44 and 4.09 q ha^{-1} over Swati and Mangla, respectively (Patel *et al.,* 1999). At Udaipur, Lok-1 produced significantly higher grain yield by 3.3 per cent over Raj-3077 (Bairwa, 1999). At the same location, var. GW-173 recorded 4.01 q higher grain yield ha^{-1} over Raj-3077 (Kulhari, 1999). At Gurdaspur (Punjab), four wheat varieties were evaluated and PBW-373 recorded significantly higher grain yield by 30.6, 51.4 and 71.7 per cent over PBW-226, Raj-3765 and PBW-138, respectively (Sardana and Sharma, 2000). At Pantnagar (U.P.), among 12 wheat varieties var. Raj-3077 recorded the highest grain yield (Nainwal and Singh, 2000).

2.1.3.2 Straw yield : Among nine wheat varieties evaluated at

Varanasi (U.P.), var. K-68 produced the maximum straw yield (Mishra *et al.,* 1980). Variety Kalyan Sona produced higher straw yield by 6.6, 4.1 and 2.7 q ha^{-1} over HD-1553, Malaviya-12 and UP-262, respectively (Mishra and Sen, 1982). At IARI (New Delhi), varieties Raj-821, HD-2016 and Sonalika were found at par in respect of straw yield (Ram and Bhardwaj, 1983). At Udaipur, var. MPO-190 produced the highest straw yield (82.0 q ha^{-1}) among eight varieties evaluated (Joshi and Singh, 1983). At Faizabad (U.P.), var. HUW-55 recorded the maximum straw yield followed by HUW-12, HI-784 and Sonalika. At Bhilwara, var. Kalyan Sona, Sonalika, Lok-1, HD-2236 and Raj-821 found equally efficient in this respect (Kumpawat and Rathore, 1989). At Ludhiana, var. PBW-154 recorded the maximum straw yield (Sharma and Dhillon, 1993). Bairwa (1999) at Udaipur obtained significantly higher straw yield with Lok-1 (65.4 q ha^{-1}) which was higher by 2.21 and 9.13 per cent over var. GW-190 and Raj-3077, respectively. At the same location, Kulhari (1999) recorded 3.69 q ha^{-1} higher straw yield with var. Raj-3077 over GW-173 (57.7 q ha^{-1}). Among two *durum* varieties, HI-8498 recorded 19.5 per cent higher straw yield compared to Raj-1555 (Swami, 1999). At Gurdaspur (Punjab), the maximum straw yield of 61.7 q ha^{-1} was recorded under PBW-373 (Sardana and Sharma, 2000).

2.1.4 Nutrient Content and Uptake :

Several research workers obtained significant variations in uptake of nutrients by wheat varieties (Bhardwaj and Wright, 1967; Singh *et al.,* 1967; Modgal *et al.,* 1968). Singh and Singh (1983) at Hisar estimated significant variations in N concentration of straw produced by wheat varieties. Among varieties, WH-157 and HD-2009 had higher N concentration compared to UP-270, while the maximum N uptake by straw was recorded under WH-157. Kapur *et al.* (1985) reported that among varieties (WL-711, WL-2217, DW-5023 and Span-1676), WL-2217 extracted maximum

N from soils, while the least was under Span-1676. At Udaipur, the highest nutrients status (N, P and K) was estimated in var. GW-173 among four varieties tested (Buldak, 1994). At the same location, grains of GW-173 had the highest N content (1.94%) among varieties tested (Jat, 1995). Kuntal (1997) reported that grains of Lok-1 had the higher N concentration compared to GW-173 and Raj-3077 but these varieties were at par in respect of N uptake by grains. Kulhari (1999) reported that grain and straw produced by GW-173 had significantly higher N, P and Zn content over Raj-3077. Among *durums* var. HI-8498 accumulated significantly higher N and P by 28.9 and 24.7 per cent over Raj-1555 but both the varieties failed to record perceptible variation in K accumulation (Swami, 1999).

2.1.5 Quality Parameters :

In CZ, at five locations different *durum* varieties were tested in irrrigated timely sown conditions among varieties tested, HI8498 gave 13.0 per cent protein content which was higher over check variety Raj-1555 (12.2%) [DWR, 1997). Similar results were observed by Swami (1999).

2.2 EFFECT OF AGROCHEMICALS:

2.2.1 Effect of Cycocel :

Cycocel (CCC) is one of the most successful and widely used growth retardants in western Europe for its dwarfing effect and enhanced productivity. CCC treated plants generally require less water (Goodin *et al.,* 1966) and it is also found to reduce the plant susceptibility to deficit stress (Goodin *et al.,* 1966 and Wunsche, 1970)

2.2.1.1 Plant water status : Zemanek (1967) reported that foliar spray of CCC in wheat showed a higher relative water content and a weakly bound water in leaves. Increase in the amount

of bound water in shoots of wheat was also reported by Blaim and Preszlakowska (1970) with CCC seed treatment. Koval (1970) observed a decreased rate of transpiration of wheat plants with CCC seed treatment. Gadzhieva *et al.* (1970) found that the rate of decrease in transpiration was associated with reduction of gibberellic acid like substances in the wheat leaves. Zadontsev *et al.* (1970) also reported higher relative water content in leaves of wheat plants treated with CCC. A favourable effect of CCC in increasing relative leaf water amount has been observed on several crops like cotton (Durdyev, 1972) and barley (Cheema *et al.* 1975). Foliar application of cycocel in wheat showed a higher relative leaf water content (Cheema *et al.*, 1982). Ignat'ev *et al.* (1990) reported that single spray of CCC (1.5 kg ha^{-1}) at three leaf stage increased resistance to unfavourable weather conditions in dry years while two foliar sprays of CCC (1.5+1.5 kg ha^{-1}) prevented lodging in wet years. Bhat *et al.* (1990) conducted a field experiment on wheat and concluded that foliar spray of CCC at 1500 ppm significantly increased total chlorophyll content, relative water content and leaf moisture content and reduced transpiration rates over control. Foliar spray of CCC at 1000ppm caused increase in relative water content in leaves of wheat over no cycocel but decreased stomatal conductance (Pandey and Yadav, 1999).

2.2.1.2 Growth characters : Ivanova (1970) reported that CCC application decreased plant height of wheat but its effectiveness differed with ecological groups of wheat. The decrease in stem length was 17.2 per cent with spring wheat originating from moist area and only 8-11 per cent for those originating from steppe. Schultz (1971) also observed that plant height decreased significantly in wet years but not in dry years. Knapp (1986) noted that chlormequat reduced plant height over control. Cycocel reduced plant height on an average by 11 per cent and reduced lodging from 57 (untreated) to 20 per cent in treated plots. Stahli *et al.* (1995) observed

that cycocel increased flag leaf area at anthesis and increased chlorophyll content of main stem. He further observed that CCC extended grain filling period by 2 days and significantly increased net CO_2 assimilation rates during flag leaf life. CCC treated wheat plants matured later than water spray [Olumen-kun, 1996].

2.2.1.3 Yield attributes : A favourable effect of CCC application has also been observed on tiller production. Zadontsev *et al.* (1969) observed higher number of tillers per unit area and more number of spikelets per spike with CCC treatment. Bokhari and Younger (1971) also recorded higher number of tillers per plant. Wunsche (1973) showed that CCC application significantly increased the number of tillers in spring wheat. Number of tillers was significantly increased by application of cycocel at tillering (Myhre *et al.*, 1973) or 20 DAS (Srivastava and Bansal, 1975). Application of cycocel in wheat reduced 1000-grain weight but increased other yield components (Dziamba, 1987). Wilhelm *et al.* (1988) conducted an experiment on wheat and concluded that spraying of CCC did not alter yield components but generally increased specific weight. Ignat'ev *et al.* (1990) observed that single foliar spray of CCC at 3 leaf stage resulted in increased leaf area, reduced flower abortion from lower spikelets and greater spike retention after flowering but CCC had no effect on grain weight or harvest index of wheat. An application of cycocel at 12 mg significantly increased the number of fertile spikelets per ear and grains per ear over control in wheat (Gendy, 1991). Singh and Saxena (1991) found that total number of fertile tillers, spikelets per spike and 1000-grain weight increased significantly due to application of cycocel. Kolev and Terziev (1996) observed that foliar spray of cycocel significantly increased the number of spikelets and grains per spike, grain weight per spike, 1000-grain weight and glassiness of wheat over control (water spray). Mandal *et al.* (1997) found that two spraying of CCC (100ppm) produced more number of

flowers and pods than single spray in green gram. Wheat plants sprayed with CCC had greater leaf area at late harvest and greater number of reproductive tillers as compared to control (Sajo and Kabura, 1998).

2.2.1.4 Yield : Increases in yield of wheat by CCC application have been attributed to prevention of lodging (Vez, 1968 and Tamini and Younis, 1972). However, experimental evidence indicates that CCC increases grain yield of wheat even when no or negligible lodging occurs (Srivastava *et al.,* 1968). Lowe and Carter (1970) and Phil-Potts (1972) attributed higher yield obtained with CCC to higher number of grains per ear. Pinthus and Rudich (1967) attributed higher grain yield with CCC foliar spray due to delay in senescence and larger number of spikes per plant, while Srivastava and Bansal (1975) attributed higher grain yield of CCC treated wheat plants to more number of tillers per plant. Dziamba (1987) found that spraying chlormequat on wheat at tillering stage increased grain yield.

Dolgodovarov and Turverkov (1987) attributed higher grain yield of wheat with CCC foliar spray in combination with urea or 2,4-D due to increased resistance to lodging. Wilhelm *et al.* (1988) also reported that chlormequat chloride reduced lodging and gave average grain yield increase of 12 per cent over control (water spray). Ignat'ev *et al.* (1990) observed that plant treated with CCC produced significantly higher grain yield of wheat over control (no cycocel). Rossolov *et al.* (1990) reported that foliar spray of cycocel @ 2 ml litre^{-1} gave yield of 4.55 tonnes compared to 2.11 tonnes for water spray. The plots treated with CCC produced significantly higher grain yield of wheat by 16.6 per cent over control (Llovers *et al.,* 1990). Llovers *et al.* (1990) observed the mean yield of wheat (2.32 t ha^{-1}) without CCC and 2.61 to 2.71 t ha^{-1} with foliar spray (1.5 kg or 2.0 kg ha^{-1}) at tillering. Bhat *et al.* (1990) reported that spraying CCC (1500ppm) significantly

enhanced grain yield of wheat over control (water spray).Gendy (1991) attributed higher grain yield of wheat with cycocel spray over control. Rossarola *et al.* (1993) observed that grain yield and harvest index of wheat crop increased linearly with chlormequat @ 1000g at tillering stage. Kler and Dhillon (1993) conducted an experiment on groundnut and found that spraying of 50 and 100ppm cycocel gave pod yield of 1.96 and 1.58 t ha^{-1}, respectively compared with yield of 1.79 t ha^{-1} in control (water spray). Giridhar and Giri (1997) observed that application of chlormequat chloride (CCC) @ 0.5 ml $litre^{-1}$ enhanced yield of groundnut by 17 per cent over control. Afria *et al.* (1998) found that spraying of cycocel significantly increased seed yield of guar (*Cyamopsis tetragonoloba*) compared to no spray. Pandey and Yadav (1999) found that spraying cycocel 1000ppm significantly increased grain yield of wheat over water spray.

2.2.1.5 Grain quality : Primost (1970) reported that grain quality was not affected by CCC treatment. Chlorminski (1972) concluded that CCC treated plants showed a slight increase in grain protein or remained unaffected. Cheema *et al.* (1982) observed that cycocel applications improved protein content of grains and N and P uptake by wheat plants. Gendy (1991) observed CCC treated wheat plants had higher protein yield over control. Chlormequat increased grain protein by 7-11 per cent (Ma *et al.,* 1994). Kandalam and Giri (1999) concluded that application of CCC significantly increased N content in kernel only in groundnut and the response was restricted upto 500ppm.

2.2.2 Effect of Thiourea :

Thiourea is a urea like compound in which 'S' is substituted for 'O' in the molecule (NH_2)=CS. It contains 36.8 per cent N and 42.1 per cent S. However, it ha been designated as sulphydryl compound (Jocelyn, 1972).

2.2.2.1 Growth characters : Narang (1988) reported that foliar spray of 0.1 per cent thiourea on gram significantly increased dry matter accumulation per plant at 50 per cent flowering stage. However, number of branches per plant did not differ significantly as compared to control. Sharma (1988) observed that foliar spray of 0.2 per cent thiourea at grain initiation in pearl millet significantly increased dry matter accumulation per plant, LAI and number of green leaves per plant over control (water spray). However plant weight was not significantly influenced by thiourea spray. Mahavar (1989) working on mustard reported that foliar spray of 0.2 per cent thiourea significantly increased the dry matter production per plant, leaf area index and plant height over control. However, number of branches per plant were not significantly influenced by foliar spray of thiourea. Sachan (1991) found that foliar spray of 500 ppm thiourea increased dry matter accumulation per plant, LAI and number of green leaves per plant at physiological maturity in maize. Sahu *et al.* (1993) reported that foliar spray of 0.1 per cent thiourea when applied at vegetative stage (30 and 45 DAS) in maize caused significant increases in LAI and number of green leaves per plant. Foliar application of 1000 ppm thiourea significantly increased crop growth and dry matter partitioning compared to water spray in pearl millet (Parihar, 1994). Sahu and Singh (1995) observed that foliar spray of thiourea (0.5 kg ha^{-1}) improved dry matter partitioning to grains and enhanced metabolic transport of sucrose to the grains via effects on phloem loading. Singh (1996) reported that spraying thiourea in maize significantly increased total chlorophyll, LAI, green leaves per plant over control (water spray).

2.2.2.2 Yield attributes : Narang (1988) conducted a field experiment on bengal gram and concluded that foliar spray of 0.1 per cent thiourea significantly increased number of pods per plant and seed index in the crop over control. However, number of branches

per plant and number of seeds per pod were not significantly influenced by thiourea spray. Sharma (1988) reported significant increases in grain weight per earhead, test weight and number of grains per earhead of pearl millet due to foliar spray of 0.2 per cent thiourea as compared to control. The number of kernels per pod and pod yield of groundnut were significantly increased due to foliar spray of 0.2 per cent thiourea over control. However, number of pods per plant and seed index were not significantly influenced by thiourea spray (Verma, 1989). Mahavar (1989) while working on mustard reported that seed yield per plant, 1000-grain weight and number of siliquae per plant were found to significantly increased as a result of foliar spray of 0.2 per cent thiourea. However, number of seeds per siliqua was not significantly influenced due to the spray. Yield components of maize viz., length of cob, number of grains per cob and grain weight per cob also increased by spray of thiourea over control (Sachan, 1991). At Almora, foliar spray of thiourea (0.1%) and water spray were found non- significant in influencing all the yield attributing parameters in maize crop (AICMIP, 1994). Similarly, at Udaipur (Raj.), foliar application of 0.1 per cent thiourea at tassel and grain formation produced significantly higher test weight over water spray, but plants treated with it attained a significantly lower plant height compared to water spray (AICMIP, 1994).

Parihar (1994), at Jodhpur, reported that foliar application of 1000 ppm thiourea significantly increased yield components including 1000-grain weight of pearl millet compared to water spray. Sahu and Singh (1995) observed that foliar spray of thiourea (0.5 kg ha^{-1}) at tillering stage significantly increased number of ears, grains per ear and 1000-grain weight over water spray in wheat. At Jodhpur (Raj.) Parihar *et al.* (1998) conducted experiments for three consecutive years and reported that their foliar spray of thiourea significantly improved the mean 1000- grain weight by 3.7 and 4.7 per cent, respectively over control. They further

recorded that thiourea also improved the mean ear weight by 6.1 and 8.1 per cent, respectively over control.

2.2.2.3 Yield : Pareek (1987) observed that spraying thiourea plus ferrous sulphate significantly increased grain yield of sorghum by 21.86 to 46.48 per cent in comparison to the foliar spray of ferrous sulphate alone and control. Foliar application of thiourea (0.1%) significantly increased seed yield, straw yield and harvest index of gram over control. Sharma (1988) reported that foliar spray of 0.2 per cent thiourea at grain initiation in pearl millet significantly increased grain yield by 14.4 per cent with an improved harvest index of 36 per cent against 32.1 per cent in control. On the other hand, straw yield as well as biological yield were not significantly influenced by this treatment. Verma (1989) observed that thiourea (0.2%) as foliar spray in groundnut significantly increased kernel and biological yield over water spray. Seed yield and harvest index significantly increased as a result of foliar spray of 0.2 per cent thiourea. Application of thiourea (500 ppm) produced higher grain yield by 25.4 per cent over control (Sachan, 1991). Thiourea applied at 0.1 per cent concentration as foliar spray at grain formation stage increased grain yield of maize by 34.1 per cent over control (Sahu and Solanki, 1991). They further observed that the harvest index of maize with thiourea and water spray was of the order of 42.8 and 32.6 per cent, respectively, having significant variations. Sahu *et al.* (1993) observed that foliar spray of 0.1 per cent thiourea when applied at vegetative stage (30 and 45 DAS) increased grain yield of maize by 40.6 per cent over control. Foliar spray of thiourea (0.1%) increased grain yield of maize by 12.2 per cent over control (21.2 q ha^{-1}) [AICMIP, 1994]. Similarly, work carried out at Udaipur Centre of AICMIP further confirmed that foliar application of 0.1 per cent thiourea at tassel initiation and grain formation produced significantly higher grain and stover yields (35.9 and 60.7 q ha^{-1}, respectively) over water spray.

Parihar (1994) observed that spraying thiourea at 1000 ppm significantly increased grain yield of pearl millet by 9.6 per cent in comparison to water spray (188.3 kg ha^{-1}). Foliar application *of thiourea (0.5 kg* ha^{-1}*) significantly increased grain yield of wheat* by 15.2 per cent compared to control. Parihar *et al.* (1998) conducted an experiment on pearl millet for three consecutive year and found that foliar spray and seed + foliar spray of thiourea produced significantly higher grain yields of 1.81 and 2.29 q ha^{-1} (9.6 and 12.2%) respectively over control (18.8 q ha^{-1}), while improvement in straw yield was of the extent of 6.0 and 7.7 per cent under aforesaid treatments over control (50.1 q ha^{-1}). Pandey *et al.* (2000), at Almora, reported that foliar spray of thiourea (0.1%) in maize at 10 and 20 days after tassel emergence produced a yield of 30.4 q ha^{-1} compared to 26. 5 q ha^{-1} from water spray.

2.2.2.4 Grain quality : Foliar spray of 0.1 per cent thiourea did not show significant influence on protein content of gram seed (Narang, 1988). Verma (1988) observed that spraying of thiourea (0.2%) on groundnut significantly increased protein content in groundnut seed. Sachan (1991) observed that protein content increased under thiourea treatment.

2.2.3 Succinic Acid :

Succinic acid is one of the member of Tri Carboxylic Acid (TCA) cycle operated in plants for the release of energy. Plants have some specialized pathways of carbohydrate metabolism among these Glyoxylic acid pathway is one in which the succinate is formed and here the succinate may be anaplerotic, giving rise to oxaloacetate or gluconeogenic giving rise to PEP (phosphoenol pyruvate (Smith *et al.*, 1987).

2.2.3.1 Growth characters : Rao (1977) observed that foliar spray of succinic acid (500-700ppm) at tillering stage in wheat significantly

increased total number of tillers, leaves and leaf area over water spray. He further reported that succinic acid (500-700ppm) accelerated maturation by 3 days and decreased lodging. Soaking seeds of safflower in succinic acid (2%) significantly decreased number of secondary branches per plant over control (Deokar *et al.*, 1981). Shanmugan (1992) reported that an application of 0.1 per cent succinic acid as seed treatment followed by its 0.1 per cent foliar spray produced higher dry matter over water spray in cotton. At Coimbatore, rice seeds treated with succinic acid (100ppm) resulted in higher number of seedlings at every stage of observation from 6 to 42 DAS in comparison to untreated seeds, showing its role in drought mitigation (Sankaran and Mathew, 1994). Mikhailova *et al.* (1997) reported that soaking barley seeds in succinic acid (0.5%) significantly increased leaf area by 35 per cent and chlorophyll content by 43 per cent as well as plant height by 7 per cent over control.

2.2.3.2 Yield attributes : Kaul *et al.* (1974) found that single foliar spray of succinic acid at 50ppm at flower initiation on green gram reduced flower shedding but increased number of pods per plant and 1000-grain weight over control. Rao (1977) also observed that foliar spray of 500-700ppm succinic acid at tillering stage significantly increased total number of tillers, grains per ear and 1000-grain weight over water spray in wheat. Succinic acid (2%) did not significantly influence the yield components of safflower (Deokar *et al.*, 1981). Bhatnagar (1983) recorded 43.25, 14.62 and 7.15 per cent increases in number of pods per plant, number of seeds per pod and 1000-grain weight, respectively over control in green gram when the crop was treated with succinic acid at the rate of 50ppm. Barley plants treated with succinic acid (0.5%) produced significantly more tillers per plant by 16 per cent over control (Mikhailova *et al.*, 1997).

2.2.3.3 Yield : Kaul *et al.* (1974) reported that single spray of succinic acid (50ppm) produced significantly higher yield of green gram by 33 per cent over control. Rao (1977) conducted a field experiment and concluded that application of 500-700ppm succinic acid as foliar spray at tillering stage significantly increased grain yield of wheat by 12 per cent over control. Deokar *et al.* (1981) observed that succinic acid (2%) did not cause any significant increase in seed yield of safflower. Bhatnagar (1983) found that spraying of 50ppm succinic acid significantly increased grain yield of green gram over control. Foliar spray of succinic acid (0.1%) increased the seed cotton yield per plant over control (Shanmugan, 1992). Mikhailova *et al.* (1997) attributed higher grain yield of succinic acid treated barley plants to more number of tillers per plant. Sabir-Ahamed (1999) observed that an application of succinic acid (20ppm) as seed treatment in green gram significantly increased seed yield by 12.6 per cent over untreated control.

2.2.3.4 Grain quality : Kirillova (1973) observed that soaking seeds in succinic acid solution increased the total N content and protein N in spring wheat leaves at all stage of development specially at stem elongation. He further observed that it also increased total N content in grain from 2.10 to 2.35 per cent and protein N from 2.03 to 1.29 per cent.

3. MATERIALS AND METHODS

A field experiment on "Effect of Agrochemicals on Growth, Yield and Quality of *aestivum* and *durum* Wheat Varieties Under Limited Irrigation Conditions" was conducted during *rabi*, 2000-2001. The details of the experimental techniques adopted, materials used and criteria used for treatment evaluation during the course of investigation are described in this chapter.

3.1 EXPERIMENTAL SITE :

The experiment was conducted in plot B_1 of the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur during *rabi* 2000-2001.

Udaipur is situated in the lap of Aravali hills at 24°34'N latitude and 73°42'E longitude at an altitude of 582.17 metre above the mean sea level. This region falls under the agroclimatic zone IV A (Sub-humid Southern Plain and Aravali Hill Region) of the Rajasthan.

3.2 WEATHER CONDITIONS :

This zone has a typical sub-tropical climate, characterized by mild winters and moderate summers with higher relative humdity during the months of July to September. The average rainfall of Udaipur is 637mm most of which received during the last week of June to September. Winter showers occur occasionally.

The maximum and minimum temperature during the crop growing season fluctuated between 24.2 to 35.7°C and 4.0 to 20.4°C, respectively. Like wise, maximum and minimum relative humidity ranged between 38 to 91 per cent and 10 to 57 per cent, respectively. The total amount of rainfall received during the crop growing season was 5.0mm. The mean weekly meteorological data recorded during the period of investigation are presented in Table 3.1 and depicted in Fig.3.1.

Table 3.1 Mean weekly meteorological parameters during the crop growth period (*rabi* 2000-2001)

Std. week No.	Duration	Temp (°C) Max	Temp (°C) Min	RH(%) Max	RH(%) Min	Sun-shine hrs/ day	Total rain-fall (mm)	Evapo-ration (mm/ day)
Year 2000 :								
45	5-11 Nov	33.0	13.7	75	35	9.4	0.0	4.1
46	12-18 Nov	31.9	13.4	81	43	9.7	0.0	4.3
47	19-25 Nov	30.4	10.6	84	48	9.8	0.0	4.0
48	26 Nov-2 Dec	25.9	8.7	82	51	9.6	0.0	3.6
49	03-09 Dec	28.9	6.8	83	48	9.9	0.0	2.9
50	10-16 Dec	28.7	8.1	81	45	9.7	0.0	3.2
51	17-23 Dec	28.1	8.0	87	48	9.6	0.0	2.8
52	24-31 Dec	27.5	7.4	88	57	8.4	0.0	2.4
Year 2001 :								
01	01-07Jan	26.7	5.5	91	50	9.2	0.0	3.0
02	08-14 Jan	24.2	5.2	91	40	9.7	0.0	2.7
03	15-21 Jan	26.3	6.8	86	45	9.8	0.0	3.0
04	22-28 Jan	25.0	4.0	84	43	10.0	0.0	3.4
05	29 Jan-04 Feb	27.6	7.5	81	45	9.2	0.0	3.9
06	05-11 Feb	28.6	6.1	85	38	10.0	0.0	3.5
07	12-18 Feb	28.3	8.5	83	20	9.9	0.0	4.3
08	19-25 Feb	31.1	12.7	71	17	10.0	0.0	5.7
09	26 Feb-4 Mar	28.6	12.0	52	22	9.0	0.0	5.1
10	05-11 Mar	30.7	9.7	50	13	9.9	0.0	5.2
11	12-18 Mar	33.0	15.2	59	21	9.7	0.0	6.1
12	19-25 Mar	34.0	16.4	56	19	9.3	0.0	7.5
13	26 Mar-1 Apr	32.9	17.8	45	17	10.3	0.0	8.7
14	2-8 Apr	35.5	16.5	38	10	10.8	0.0	7.9
15	9-15 Apr	35.7	20.4	46	26	9.7	3.2	10.7
16	16-22 Apr	34.2	18.7	51	21	9.5	1.8	8.0

Source : Agromet Observatory, Instructional Farm, Deptt. of Agronomy, RCA, Udaipur.

FIG.3.1 MEAN WEEKLY METEOROLOGICAL PARAMETERS DURING CROP GROWING SEASON (RABI, 2000-2001)

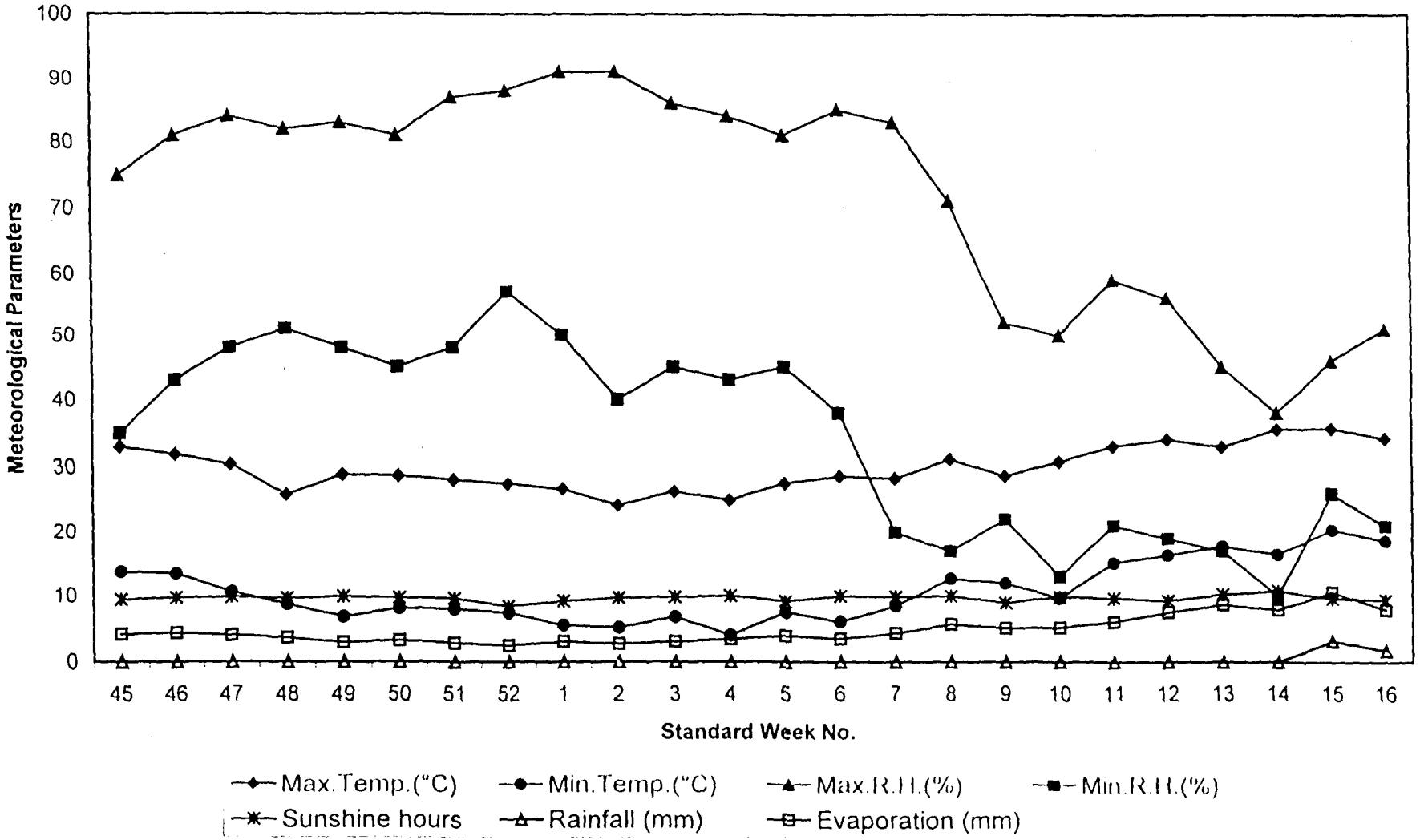


Table 3.2 Physico-chemical properties of soil of the experimental field

Properties	Value	Method employed
A. Mechanical composition :		
1. Course (%)	12.30	International pipette method
2. Fine sand (%)	26.95	(Piper, 1950)
3. Silt (%)	26.12	
4. Clay (%)	32.40	
5. Textural class	Clay loam	Triangular diagram (Brady, 1983)
B. Physical composition :		
1. Bulk density (Mg m^{-3})		
Soil depth :		
0-15 cm	1.40	Core Sampler method
15-30 cm	1.48	(Piper, 1950)
30-45 cm	1.48	
2. Field capacity (%)		
Soil depth :		
0-15 cm	26.4	Field method (Piper, 1950)
15-30 cm	25.4	
30-45 cm	25.2	
3. Permanent wilting point (%) :		
Soil depth :		
0-15 cm	10.0	Sunflower method
15-30 cm	10.2	(Piper, 1950)
30-45 cm	10.2	
4. Particle density (Mg m^{-3})	2.65	Black (1965)
5. Porosity (%)	44.90	Black (1965)
C. Chemical composition :		
1. Available nitrogen (kg ha^{-1})	295.00	Kjeldahl's method (Bremner, 1960)
2. Available phosphorus (kg ha^{-1})	27.02	Olsen's method (Olsen *et al.*, 1954)
3. Available potassium (kg ha^{-1})	310.00	Flame photometer (Jackson, 1973)
4. Organic carbon (%)	0.88	Walkley and Black (1947)
5. Electric conductivity (dSm^{-1} at 25°C)	0.89	Conductivity bridge (Richards, 1968)
6. pH (1:2, soil : water suspension)	8.2	Blackman's pH meter (Piper, 1950)

3.3 PHYSICO-CHEMICAL PROPERTIES OF THE EXPERIMENTAL FIELD :

The soil samples were drawn randomly before sowing from different spots in the experimental field at three successive soil layers of 0-15, 15-30 and 30-45cm depth and a composite sample was prepared. The composite sample was analysed for physico-chemical properties of the soil. The values of soil analysis along with methods followed are presented in Table 3.2

The mechanical and chemical analysis show that the soil of the experimental field was clay loam in texture, having moderately alkaline reaction. The soil was medium in available nitrogen, while high in available phosphorus as well as potassium.

3.4 CROPPING HISTORY OF THE FIELD :

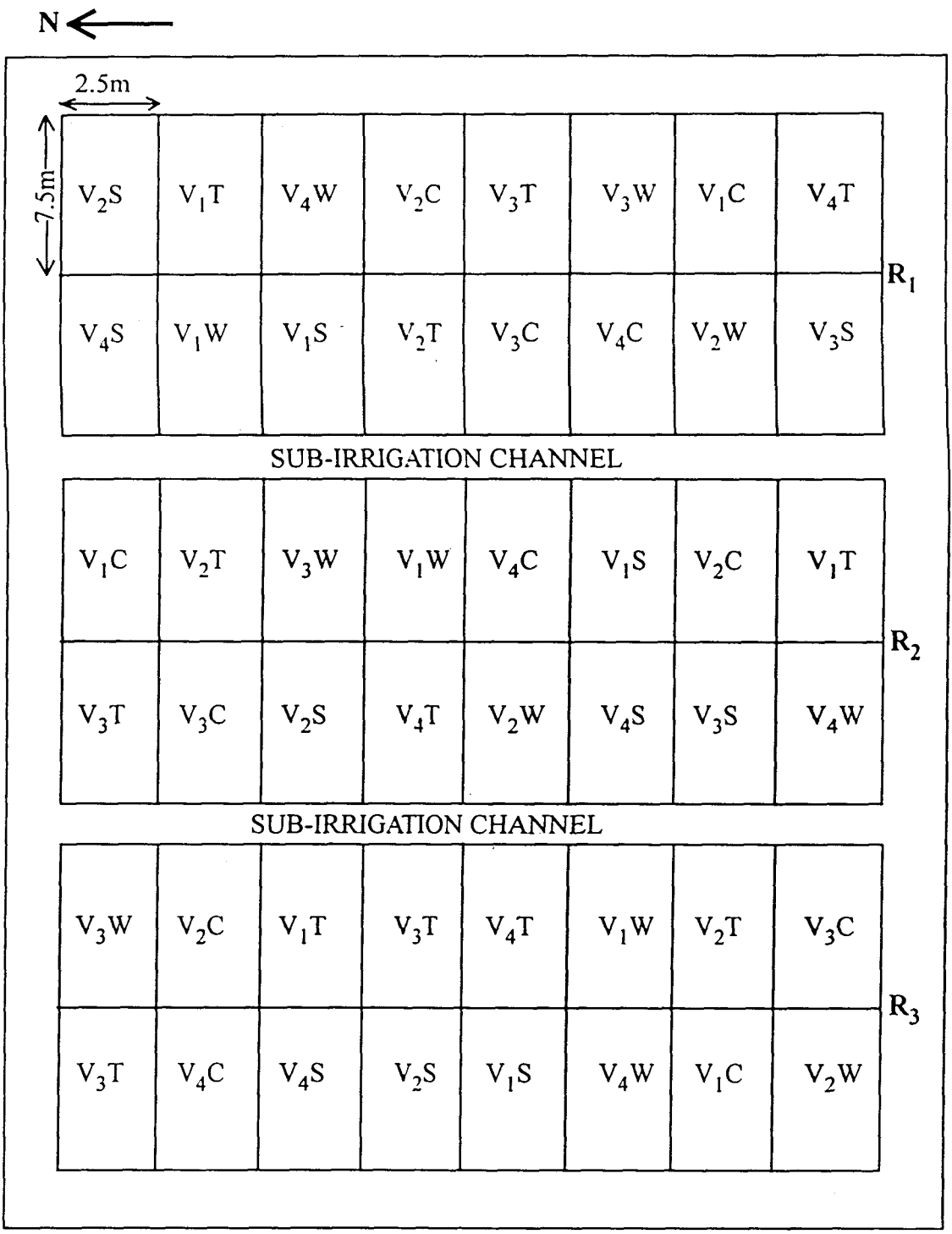
The preceding maize crop was sown during *kharif*, which was followed by the present experiment in *rabi* season (2000-2001).

3.5 EXPERIMENTAL DETAILS :

Sixteen different treamtent combinations comprising of four varieties and three agrochemicals along with one water spray (control) were tested in factorial RBD with three replications. The plan of layout is depicted in Fig.3.2. The tretments along with their symbols used are given below and the details of treatment combinations are presented in Table 3.3.

Treatments		**Symbols**
A. Varieties :		
(i)	Lok-1	V_1
(ii)	HW2004	V_2
(iii)	HW8498(d)	V_3
(iv)	A 9-30-1(d)	V_4
B. Agrochemicals :		
(i)	Water spray	W
(ii)	Cycocel 1000ppm	C
(iii)	Thiourea 1000ppm	T
(iv)	Succinic acid 1000ppm	S

FIG.3.2 PLAN OF LAYOUT



Design = RBD
Replications = 3
Gross plot size = 7mx2.5m
Net plot size = 6.0mx1.61m

Varieties :
V_1 = Lok-1
V_2 = HW2004
V_3 = HI8498
V_4 = A 9-30-1

Agrochemicals:
W = Water spray
C = Cycocel 1000ppm
T = Thiourea 1000ppm
S= Succinic acid 1000ppm

Table 3.3 Details of treatment combinations

S.No.	Symbols	Treatment combinations	
		Varieties	**Agrochemicals**
1.	V_1W	Lok-1	Water spray
2.	V_1C	Lok-1	Cycocel 1000ppm
3.	V_1T	Lok-1	Thiourea 1000 ppm
4.	V_1S	Lok-1	Succinic acid 1000ppm
5.	V_2W	HW2004	Water spray
6.	V_2C	HW2004	Cycocel 1000ppm
7.	V_2T	HW2004	Thiourea 1000 ppm
8.	V_2S	HW2004	Succinic acid 1000ppm
9.	V_3W	HI8498	Water spray
10.	V_3C	HI8498	Cycocel 1000ppm
11.	V_3T	HI8498	Thiourea 1000 ppm
12.	V_3S	HI8498	Succinic acid 1000ppm
13.	V_4W	A 9-30-1	Water spray
14.	V_4C	A 9-30-1	Cycocel 1000ppm
15.	V_4T	A 9-30-1	Thiourea 1000 ppm
16.	V_4S	A 9-30-1	Succinic acid 1000ppm

Other Treatment Details :

(i)	Total treatment combinations	:	4x4 = 16
(ii)	Experimental design	:	Randomized Block Design
(iii)	Replications	:	Three
(iv)	Total number of plots	:	16x3 = 48
(v)	Plot size :		
	Gross	:	7.0mx2.5m=17.5m^2
	Net	:	6.0mx1.61m=9.66m^2
(vi)	Rainfed/irrigated	:	Irrigated (limited)

3.6 TREATMENT APPLICATION TECHNIQUES :

3.6.1 Wheat Varieties :

The varieties were sown as per the layout. The detail characteristics of varieties are given below :

(a) Lok-1 : It is a double gene dwarf *aestivum* wheat variety. It has moderate tillering habit and is resistant to shattering. The 1000-grain weight ranges from 42 to 46 g. This variety takes about 120 days to mature. It has yield potential of 50 to 55 q ha^{-1} under normal sown conditions and 40 to 45 q ha^{-1} under late sown conditions. It is released for central wheat growing zone of country. It is suitable for cultivation under irrigated normal and late sown conditions.

(b) HW2004 : This is a single gene dwarf *aestivum* wheat variety. The 1000-grain weight ranges from 37 to 43g. It takes about 122 days to mature. It has yield potential of 15 to 20 q ha^{-1} under rainfed and 30 to 35 q ha^{-1} under restricted irrigation conditons. It is recommended for rainfed areas of central zone.

(c) HI8498 : It is the highest yielding stable *durum* wheat variety. It has high tillering habit and is highly resistant to stem rust. Average 1000-grain weight is 50g and yield is 66 q ha^{-1}. This variety takes about 120 days to mature. It is released for central wheat growing zone of country which is suitable for cultivation under normal as well as late sown irrigated conditions.

Table 3.4 Details of cultural operations carried out during crop growing period (*rabi*, 2000-2001)

S.No.	Operations	Date
1.	Field preparation	16.11.2000
2.	Layout and bunding	18.11.2000
3.	Fertilizer application :	
	(a) Placement/basal dose	19.11.2000
	(b) Top dressing of urea	14.12.2000
4.	Sowing of seeds	22.11.2000
5.	Herbicidal spray : Isoproturon @ 0.75 kg ha^{-1}	23.12.2000
6.	Irrigation :	
	(a) Irrigation at sowing	22.11.2000
	(b) First irrigation (CRI)	14.12.2000
	(c) Second irrigation (anthesis)	18.02.2001
7.	Foliar spray of agrochemicals	06.01.2001
8.	Harvesting	20.04.2001
9.	Threshing and winnowing	30.04.2001

(d) A 9-30-1 : It is a tall improved *durum* wheat variety. The average 1000-grain weight is 41g with yield potential of 30 to 40 q ha^{-1}. It is medium late in maturity, grains are amber and semi-hard. It was released in 1970 for rainfed areas of eastern Rajsathan and Madhya Pradesh.

3.6.2 Agrochemicals :

One foliar spray of each agrochemical at 1000ppm was done at the maximum tillering stage of the crop (40-45 DAS) as per the treatment/layout plan. In control plots, water spray was done @ 250 litre ha^{-1}. The details of agrochemicals are given below :

(a) Cycocel : Cycocel (CCC) is one of well known growth retardants and it retards vegetative growth by lowering of auxins levels in plants (Kurashi and Muir, 1963).

(b) Thiourea : It is a sulphydryl compound containing one SH group. The SH group has been implicated in photosynthate translocation in crop plants (Giaqanta, 1976).

(c) Succinic acid : Succinic acid is one of the member of TCA cycle operated in plants for release of energy (Smith *et al.,* 1987).

3.7 DETAILS OF CROP RAISING :

The details of crop raising are given in Table 3.4 and interpreted as under :

3.7.1 Field Preparation :

Immediately after harvest of the preceding maize crop, a pre-sowing irrigation was given in the experimental plot. At the right soil moisture content, the field was well pulverized by

giving one deep ploughing with a tractor drawn disc plough followed by cross harrowing and one planking. The plot was properly levelled and the experiment was laid out making provision for irrigation channels. After bunding, individual plot was levelled and prepared for sowing.

3.7.2 Fertilizer Application :

A uniform basal dose of 40 kg N ha^{-1} through urea after subtracting N available from DAP and full dose of phosphorus (40 kg P_2O_5 ha^{-1}) through DAP were applied in furrows of individual plot at a depth of 8-10cm. The remaining 40 kg N ha^{-1} through urea was top dressed at the time of first irrigation (21 DAS).

3.7.3 Seed and Sowing :

The seed of two varieties each of *aestivum* and *durum* wheat were sown as per the layout in lines at 22.5cm apart at 5cm depth, using computed quantity of seed, based on test weight in comparison to the standard test weight of Kalyan Sona (38g), 100 kg ha^{-1}. The seed rates worked out for the test varieties Lok-1, HW2004, HI8498 and A 9-30-1 were 119.50, 108.70, 127.10 and 107.60 kg ha^{-1}, respectively.

3.7.4 Irrigation :

Immediately after sowing one irrigation was given to experimental field to facilitate germination. Later on two irrigations each of 70mm were given to the crop - first irrigation at CRI and second at anthesis.

3.7.5 Herbicidal Application :

The crop was kept weed free by post-emergence application of isoproturon @ 0.75 kg ha^{-1} at 30 DAS.

3.7.6 Harvesting and Threshing :

The crop was harvested from the individual plot as per its physiological maturity which varied with varieties. Borders

of 0.45m in width consisting of two rows on each side of the plot and 0.5m strip on either side of 7m row length of gross plot were harvested as border area. The remaining plants in the net plot of 6.0mx1.61m were harvested. The harvested plants were bundled and tagged. After complete sun drying on threshing floor, bundles were weighed just before threshing to record biological yield. Thereafter, threshing of the produce of each plot was done separately with a power operated thresher and grain yield per plot thus obtained was winnowed, cleaned and weighed.

3.8 TREATMENT EVALUATION :

3.8.1 Biometric Studies :

(A) Growth and phenological development :

(i) Germination count : Number of plants m^{-1} row length were counted after complete germination (10 DAS) from three randomly selected places in each plot area.

(ii) Total tillers m^{-1} row length : Number of tillers m^{-1} row length were counted at maximum tillering (40-45 DAS) from three randomly selected sites in each plot.

(iii) Plant height : At physiological maturity, height of five randomly tagged plants from each plot was measured from base of plant to the tip of upper spikelet of main ear (excluding awns). The mean height of plants was computed for each treatment and expressed in centimetre.

(iv) Dry matter accumulation : The periodical changes in dry matter accumulation at successive growth stages viz., maximum tillering, anthesis and physiological maturity were recorded by collecting whole plant samples from randomly selected 0.5m row length in each plot at each aforesaid duration. These were chopped and dried in oven at 70°C for 72 hours till a constant weight was

noted. Thereafter, the samples were weighed and averaged to work out dry matter accumulation m^{-1} row length at each of the above mentioned growth stages.

(v) CGR and RGR : The growth efficiency parameters namely, CGR and RGR, were estimated at peak vegetative (maximum tillering-anthesis) and reproductive (anthesis-maturity) growth stages of the crop. These were computed by using formula advocated by Ready and Reddi (1992).

(a) Crop growth rate (CGR) :

$$CGR\ (g\ m^{-2}\ day^{-1}) = \frac{W_2 - W_1}{t_2 - t_2}$$

Where, W_1 and W_2 are dry weight m^{-2} area at time t_1 and t_2, respectively.

(b) Relative growth rate (RGR) :

$$RGR\ (g\ g^{-1}\ DM\ day^{-1}) = \frac{Log_n W_2 - Log_n W_1}{t_2 - t_1}$$

Where, W_1 and W_2 are dry weight m^{-2} at time t_1 and t_2, respectively.

(vi) Phenological stages : The number of days required for initiation of different successive phenological stages (germination, tillering, boot, heading and maturity) were recorded when 75 per cent of all plants in that particular plot reached the specified growth stage.

(B) Yield attributes :

(i) Effective tillers : At physiological maturity, only effective (ear bearing) tillers were counted from the same row length selected

for counting of the total number of tillers to estimate average number of effective tillers m^{-1} row length.

(ii) Ear length : Ten ears randomly collected from each plot for recording ear length, grains per ear and grain weight per ear. The length of ear was measured in centimetre from basal spikelets to tip of upper spikelet (excluding awns). The average length from each plot was worked out.

(iii) Grains per ear : The above mentioned ten ears were threshed and grains were counted to determine average number of grains per ear.

(iv) Grain weight per ear : The grains obtained from the above mentioned ears were weighed and average grain weight per ear was computed.

(v) 1000-grain weight : Wheat grain samples were drawn from the produce after weighing of each net plot yield. From these, 1000-grains were counted and weighed on an electric top pan balance and expressed in gramme.

(C) Yield and harvest index :

(i) Biological yield : After complete drying, total unthreshed produce from each net plot was weighed to record biological yield and then computed in terms of q ha^{-1}.

(ii) Grain yield : After threshing and winnowing, grain yield obtained from each net plot was weighed and recorded as grain in kg per plot and then converted to q ha^{-1}.

(iii) Straw yield : Straw yield was computed by subtracting the corresponding grain yield from the biological yield and expressed in terms of q ha^{-1}.

(iv) Harvest index : Harvest index is the ratio of economic yield to the biological yield, which was worked out by following formula (Donald and Hamblin, 1976) and expressed in percentage.

$$HI\ (\%) = \frac{\text{Economic yield (q ha}^{-1})}{\text{Above ground biological yield (q ha}^{-1})} \times 100$$

3.8.2 Biochemical Studies :

(i) Nitrogen content : Grain and straw samples were collected at harvest from each plot and dried in oven at 70°C till a constant weight. After that, the samples were ground separately with a grinder and nitrogen content in grain as well as straw were determined by adopting the following standard method :

(i) Nitrogen content : Nessler's reagent colorimeteric method (Lindner, 1944).

(ii) Nitrogen uptake : Nitrogen uptake was estimated by using the following formula :

$$\text{Nitrogen uptake by grain (kg ha}^{-1}) = \frac{\text{N content in grain (\%) x Grain yield (kg ha}^{-1})}{100}$$

$$\text{Nitrogen uptake by straw (kg ha}^{-1}) = \frac{\text{N content in straw (\%) x Straw yield (kg ha}^{-1})}{100}$$

3.8.3 Quality Parameters :

Protein content : The protein content of grain was worked out by multiplying nitrogen content in grain (%) with factor 6.25 (A.O.A.C., 1960).

3.8.4 Consumptive Water Use :

Soil moisture extracted from each soil layer **i.e.,** 0-

15, 15-30 and 30-45cm depths during the crop growing period was calculated from each plot as per procedure suggested by Dastane (1972). The total consumptive use water was worked out by summing up the moisture extracted from aforesaid three soil depths.

$C\mu = \Sigma\mu$ = Seasonal Consumptive use of water (mm)

$$\mu = (E_0 \times 0.8) + \sum_{i=1}^{n} \frac{M_{1i} - M_{2i}}{100} \times A_i \times D_i + ER + GWC$$

Where,

μ = Consumptive use of water during a given period (mm)

E_0 = Evaporation (mm) from USWB class A pan evaporimeter during interval from the day of irrigation to the day when sampling in wet soil was possible (48 hr in this case)

0.8 = A constant to be used with USWB class A pan evaporimeter

n = Number of soil layers sampled in the root zone

M_{1i} = Soil moisture (%) in the i^{th} layer on the day when sampling in irrigated soil was possible

M_{2i} = Soil moisture (%) in the i^{th} layer on the day just before the next irrigation

A_i = Apparent specific gravity of the i^{th} layer (g/cc)

ER = Effective rainfall during the interval (mm)

GWC= Ground water contribution : The ground water contribution was treated as negligible because during rabi season the water table was below 10m.

3.8.5 Water Use Efficiency :

Water use efficiency of different treatments was calculated as defined by Viets (1962) i.e., quantity of economic produce per unit of water consumed. This was calculated by using the following equation :

$$WUE = \frac{Y}{ET}$$

Where,

WUE = Water use efficiency (kg grain mm^{-1} ha^{-1})

Y = Yield of grain (kg ha^{-1})

ET = The consumptive use of water (mm)

3.9 STATISTICAL ANALYSIS :

The experimental data were statistically analysed for analysis of variance and test of significance through the procedure appropriate to the Randomized Block Design as described by Cocharan and Cox (1957). The critical difference (CD) for comparing treatment mean was worked out wherever the F test was found significant at 5 per cent level of significance. Summary table along with SEm± and CD were prepared as presented in the text of the chapter entitled "Experimental Results" and analysis of variance for different parameters are presented in "Appendices" at the end. Further, to determine relationship between various parameters, the correlation coefficient and regression equation were worked out as described by Panse and Sukhatme (1985).

3.10 ECONOMICS :

To find out the most profitable treatment, economics of different treatments were worked out in terms of net returns ha^{-1}. Benefit : cost (B:C) ratio was also calculated treatment wise to ascertain economic viability of the treatments. The details are depicted in Appendix-XI.

4. EXPERIMENTAL RESULTS

Results of the field experiment entitled "Effect of Agrochemicals on Growth, Yield and Quality of *aestivum* and *durum* Wheat Varieties Under Limited Irrigation Conditions" are presented in this chapter along with statistical inferences. Data pertaining to the effect of different treatments on growth and phenological development, yield attributes, yield, water use, nutrient content and uptake were subjected to statistical analysis to test the significance of results. Analysis of variance tables for these data are appended at the end (Appendices I to XI). Results of all main effects and interactions which were found significant are presented in this chapter.

4.1 EFFECT OF VARIETIES AND AGROCHEMICALS ON GERMINATION COUNT, GROWTH AND PHENOLOGICAL DEVELOPMENT :

Data on number of plants m^{-1} row length at 10 DAS, growth and phenological development under influence of treatments are presented in Table 4.1 to 4.4 and their relevant analysis of variance are given in Appendices I to IV.

4.1.1 Germination Count :

Varieties : Data presented in Table 4.1 indicate that varieties failed to produce significant effect on germination count of the crop.

4.1.2 Total Tillers m^{-1} row length :

Varieties : Data (Table 4.1) show that *aestivum* wheat variety HW2004 was found at par with check variety Lok-1 in respect

Table 4.1 Effect of varieties and agrochemicals on growth characters

Treatments	Germination count m^{-1} row length	Total tillers m^{-1} row length	Plant height at harvest(cm)
Varieties :			
Lok-1	41.66	167.08	80.08
HW2004	41.33	175.83	88.06
HI8498	41.50	182.25	81.80
A 9-30-1	41.50	164.17	78.19
SEm±	0.75	4.05	1.47
CD at 5%	NS	11.67	4.25
Agrochemicals :			
Water spray			81.82
Cycocel			75.71
Thiourea			86.97
Succinic acid			83.62
SEm±			1.47
CD at 5%			4.25

of total tillers at maximum tillering. Further, *durum* wheat variety HI8498 recorded significantly the highest number of total tillers m^{-1} row length (182.25) except *aestivum* wheat variety HW2004.

4.1.3 Plant Height at Harvest :

Varieties : It is evident from data (Table 4.1) that *aestivum* wheat variety HW2004 recorded significantly the highest plant height (88.06cm) at harvest. Whereas, the rest of varieties were observed at par in this respect.

Agrochemicals : Data (Table 4.1) explicitly show that foliar spray of cycocel produced significantly the lowest plant height (75.71cm) among the agrochemicals. Further, foliar spray of thiourea gave significantly higher plant height over water spray. Whereas, the foliar spray of succinic acid was found at par with both water spray and foliar spray of thiourea.

4.1.4 Dry Matter Accumulation at Successive Growth Stages:

Varieties : A perusal of data (Table 4.2) reveals that *durum* wheat variety HI8498 produced significantly the highest dry matter at successive growth stages *viz.*, at maximum tillering, anthesis and at harvest. At maximum tillering and at harvest, *aestivum* wheat varieties were observed at par in respect of dry matter accumulation. While at anthesis, *aestivum* wheat variety HW2004 accumulated significantly higher dry matter over check variety Lok-1.

Agrochemicals : It is clear from data (Table 4.2) that foliar sprays of agrochemicals did not significantly influence dry matter accumulation at maximum tillering, while at anthesis, foliar spray of cycocel gave significantly the highest dry matter. Further, foliar sprays

Table 4.2 Effect of varieties and agrochemicals on dry matter accumulation at successive growth stages (g m^{-1} row length)

Treatments	At maximum tillering (45 DAS)	At anthesis	At harvest
Varieties :			
Lok-1	20.39	154.75	209.15
HW2004	21.04	161.85	218.41
HI8498	22.52	169.04	231.40
A 9-30-1	19.17	149.32	200.90
SEm±	0.47	2.24	4.29
CD at 5%	1.35	6.47	12.41
Agrochemicals :			
Water spray	20.81	144.70	199.82
Cycocel	20.91	169.52	226.11
Thiourea	20.93	162.96	220.49
Succinic acid	20.48	157.76	213.44
SEm±	0.47	2.24	4.29
CD at 5%	NS	6.47	12.41

of thiourea and succinic acid were observed at par in this respect and both these treatments produced significantly higher dry matter over water spray. At harvest, foliar sprays of agrochemicals produced significantly higher dry matter over water spray. The maximum dry matter was recorded with foliar spray of cycocel, which was significantly higher over foliar spray of succinic acid but at par with thiourea. Foliar spray of cycocel recorded significantly higher dry matter at harvest by 13.15, 2.54 and 5.93 over control (water spray), thiourea and succinic acid sprays, respectively.

4.1.5 Growth Efficiency Parameters :

Varieties : An examination of data (Table 4.3) reveals that *aestivum* check variety Lok-1 recorded the maximum CGR (16.52 g m^{-2} day^{-1}) from tillering to anthesis and was closely followed by HI8498 (15.83 g m^{-2} day^{-1}) and HW2004 (15.31 g m^{-2} day^{-1}) and all these three varieties gave significantly higher CGR over variety A 9-30-1. Significantly the highest RGR (0.623 g g^{-1} DM day^{-1}) was obtained with variety Lok-1 and the rest varieties were observed at par in this respect. Further, varieties did not differ significantly in respect of CGR and RGR between anthesis to maturity stages.

Agrochemicals : Data (Table 4.3) show that foliar spray of cycocel at the maximum tillering produced significantly the highest values of CGR (17.76 g m^{-2} day^{-1}) and RGR (0.0625 g g^{-1} DM day^{-1}) recorded between tillering to anthesis stages. Further, foliar spray of thiourea also gave significantly higher value of CGR recorded between tillering to anthesis over water spray. Further, foliar spray of thiourea as well as succinic acid were observed at par with water spray in respect of RGR recorded between tillering to anthesis. Between anthesis to maturity, values of CGR and RGR were not significantly influenced with foliar sprays of agrochemicals.

Table 4.3 Effect of varieties and agrochemicals on growth efifciency parameters

Treatments	CGR (g m^{-2} day^{-1})		RGR (g g^{-1} DM day^{-1})	
	Tillering to anthesis	Anthesis to maturity	Tillering to anthesis	Anthesis to maturity
Varieties :				
Lok-1	16.52	5.26	0.0623	0.0073
HW2004	15.81	4.95	0.0554	0.0065
HI8498	15.83	5.80	0.0544	0.0073
A 9-30-1	14.42	4.67	0.0566	0.0066
SEm±	0.45	0.50	0.0015	0.0006
CD at 5%	1.32	NS	0.0043	NS
Agrochemicals :				
Water spray	13.78	5.14	0.0539	0.0075
Cycocel	17.76	4.96	0.0625	0.0062
Thiourea	15.60	5.35	0.0564	0.0070
Succinic acid	14.96	5.24	0.0558	0.0071
SEm±	0.45	0.50	0.0015	0.0006
CD at 5%	1.32	NS	0.0043	NS

4.1.6 Phenological Stages :

Varieties : A comparison of varieties (Table 4.4) indicate that *aestivum* wheat variety HW2004 recorded significantly greater number of days to tillering initiation (29 days), booting (65.75 days), heading (76.08 days) and maturity (120.66 days) as compared with check variety Lok-1. While *durum* wheat variety HI8498 took lesser number of days to tillering initiation (27.75 days), booting (64.00 days), heading (73.25 days) and maturity (117.91 days) as compared with check variety A 9-30-1. However, varieties did not significantly influence days to germination.

Agrochemicals : Data (Table 4.4) show that foliar sprays of agrochemicals failed to produce significant effect on various phenological stages of the crop.

4.2 EFFECT OF VARIETIES AND AGROCHEMICALS ON YIELD ATTRIBUTES :

Data on various yield attributes as influenced by treatments are given in Table 4.5 and their analysis of variance in Appendix-V.

4.2.1 Effective Tillers m^{-1} row length :

Varieties : Data presented in Table 4.5 indicate that varieties HW2004 and HI8498 recorded significantly higher effective tillers m^{-1} row length over check varieties Lok-1 and A 9-30-1. Further, *durum* variety HI8498 produced the maximum number of effective tillers m^{-1} row length (129.16).

Agrochemicals : It is evident from data (Table 4.5) that foliar spray of cycocel gave significantly the highest number of effective tillers m^{-1} row length (130.58). Further, foliar spray of thiourea and succinic acid were observed at par and both these treatments gave significantly higher number of effective tillers m^{-1} row length over water spray.

Table 4.4 Effect of varieties and agrochemicals on different phenological stages

Treatments	Days to germination	Days to tillering initiation	Days to booting	Days to heading	Days to maturity
Varieties :					
Lok-1	6.08	27.33	62.75	72.33	116.41
HW2004	6.08	29.00	65.75	76.08	120.66
HI8498	6.33	27.75	64.00	73.25	117.91
A 9-30-1	6.08	29.75	66.66	77.00	122.41
SEm±	0.122	0.276	0.571	0.795	0.921
CD at 5%	NS	0.798	1.649	2.297	2.659
Agrochemicals :					
Water spray	6.25	28.00	64.25	73.83	119.08
Cycocel	6.16	28.83	65.41	75.25	119.75
Thiourea	6.08	28.58	64.83	74.83	119.41
Succinic acid	6.08	28.41	64.66	74.75	119.16
SEm±	0.122	0.276	0.571	0.795	0.921
CD at 5%	NS	NS	NS	NS	NS

4.2.2 Ear Length :

Varieties : Data (Table 4.5) show that *aestivum* wheat varieties *viz.*, HW2004 and Lok-1 were observed at par in respect of ear length. The *durum* variety HI8498 recorded significantly smaller ear length than check variety A 9-30-1.

Agrochemicals : It is clear from data (Table 4.5) that foliar spray of cycocel produced significantly greater ear length as compared to control (water spray), but was found at par with foliar sprays of thiourea and succinic acid. Foliar spray of thiourea also produced significantly greater ear length over water spray. While foliar spray of succinic acid was found at par with foliar spray of thiourea and control (water spray) in this respect.

4.2.3 Grains per ear :

Varieties : Data (Table 4.5) show that varieties HW2004 and HI8498 produced significantly higher number of grains per ear over check varieties Lok-1 and A 9-30-1.

Agrochemicals : An examination of data (Table 4.5) reveals that foliar spray of cycocel produced significantly higher number of grains per ear over water spray, but was found at par with foliar spray of thiourea and succinic acid. Foliar spray of thiourea also produced significantly higher grains per ear over water spray. However, foliar spray of succinic acid was observed at par with water spray in this respect.

4.2.4 Grain Weight per ear :

Varieties : Variety HW2004 was found at par with *aestivum* check variety Lok-1 in respect of grain weight per ear. Further, *durum* wheat variety HI8498 recorded significantly higher grain weight per ear over check variety A 9-30-1 (Table 4.5).

Table 4.5 Effect of varieties and agrochemicals on yield attributes

Treatments	Effective tillers m^{-1} row length	Ear length (cm)	Grains per ear	Grain weight per ear (g)	1000-grain weight (g)
Varieties :					
Lok-1	115.66	8.72	35.25	1.81	45.00
HW2004	125.16	8.29	41.58	1.85	45.25
HI8498	129.16	6.58	42.41	1.93	47.91
A 9-30-1	108.58	7.66	34.33	1.70	41.58
SEm±	2.682	0.151	0.836	0.032	0.523
CD at 5%	7.746	0.436	2.413	0.091	1.510
Agrochemicals :					
Water spray	106.66	7.42	36.08	1.73	42.41
Cycocel	130.58	8.06	40.41	1.88	46.25
Thiourea	122.41	7.94	39.08	1.84	45.66
Succinic acid	118.91	7.83	38.00	1.83	45.41
SEm±	2.682	0.151	0.836	0.032	0.523
CD at 5%	7.746	0.436	2.413	0.091	1.510

Agrochemicals : It is evident from data (Table 4.5) that all the agrochemicals produced significantly higher grain weight per ear over control (water spray). Foliar spray of cycocel gave the highest grain weight per ear (1.88g), but was found at par with foliar sprays of thiourea and succinic acid.

4.2.5 1000-grain weight :

Varieties : Data (Table 4.5) indicate that *durum* variety HI8498 recorded significantly the highest 1000-grain weight (47.91g), while *aestivum* variety HW2004 was found at par with check variety Lok-1.

Agrochemicals : Foliar sprays of agrochemicals namely, cycocel, thiourea and succinic acid recorded significantly higher test weight over control (water spray). However, agrochemicals were observed at par in this respect (Table 4.5).

4.3 EFFECT OF VARIETIES AND AGROCHEMICALS ON YIELD AND HARVEST INDEX :

Data on crop productivity recorded in terms of grain, straw and biological yield as well as crop efficiency i.e., harvest index, under influence of treatments are presented in Table 4.6 and corresponding analysis of variance have been given in Appendix-VI.

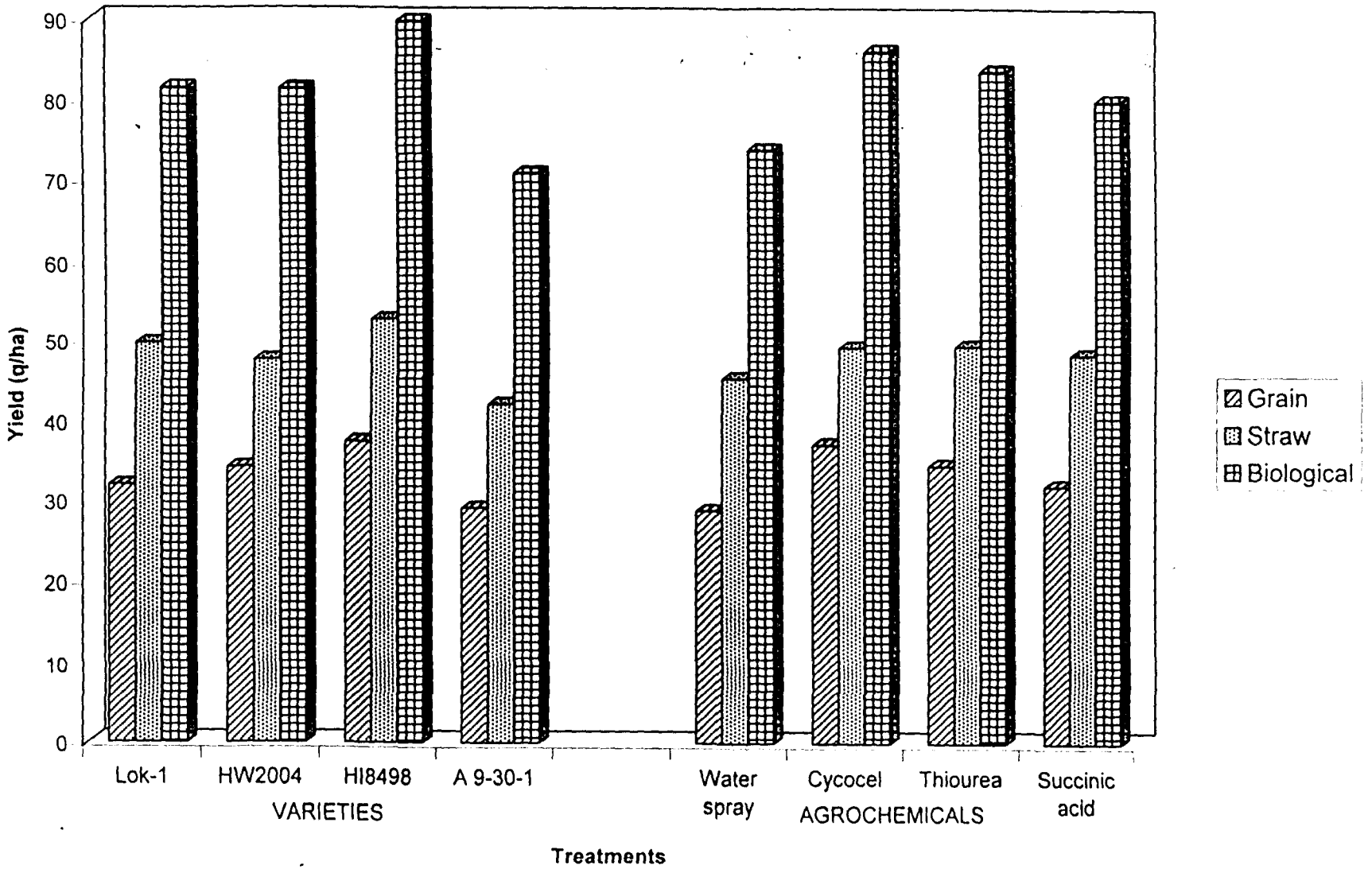
4.3.1 Grain Yield :

Varieties : Data presented in Table 4.6 show that *durum* variety HI8498 produced significantly the highest grain yield of 37.33 q ha^{-1} under limited irrigation conditions which was higher by 9.12, 16.83 and 28.63 per cent over varieties HW2004, Lok-1 and A 9-30-1, respectively. Further, *aestivum* wheat variety HW2004 gave significantly higher grain yield over check varieties Lok-1 and A 9-30-1.

Table 4.6 Effect of varieties and agrochemicals on grain, straw and biological yield and harvest index

Treatments	Grain yield ($q\ ha^{-1}$)	Straw yield ($q\ ha^{-1}$)	Biological yield ($q\ ha^{-1}$)	Harvest index (%)
Varieties :				
Lok-1	31.95	49.66	81.61	39.07
HW2004	34.21	47.38	81.60	41.81
HI8498	37.33	52.50	89.83	41.50
A 9-30-1	29.02	41.86	70.88	40.87
SEm±	0.671	0.960	1.347	0.558
CD at 5%	1.937	2.774	3.869	1.612
Agrochemicals :				
Water spray	28.75	45.10	73.85	38.92
Cycocel	37.14	49.04	86.18	43.10
Thiourea	34.60	49.19	83.79	41.28
Succinic acid	32.02	48.08	80.10	39.54
SEm±	0.671	0.960	1.347	0.558
CD at 5%	1.937	2.774	3.869	1.612

FIG.4.1 EFFECT OF VARIETIES AND AGROCHEMICALS ON YIELD



Agrochemicals : It is evident from data (Table 4.6) that foliar spray of cycocel produced significantly the highest grain yield of 37.14 q ha^{-1} which was higher by 7.34, 15.99 and 29.18 per cent over foliar spray of thiourea, succinic acid and water spray, respectively. Foliar spray of thiourea produced significantly higher grain yield over foliar spray of succinic acid and water spray by 8.05 and 20.34 per cent, respectively. Foliar spray of succinic acid also produced significantly higher grain yield by 11.37 per cent over water spray.

4.3.2 Straw Yield :

Varieties : Data (Table 4.6) show that *durum* wheat variety HI8498 produced significantly the highest straw yield of 52.50 q ha^{-1} which was higher by 5.71, 10.80 and 25.41 per cent over Lok-1, HW2004 and A 9-30-1, respectively. Variety HW2004 was found at par with *aestivum* check variety Lok-1 in this respect, but both these varieties produced significantly higher straw yield over *durum* check variety A 9-30-1.

Agrochemicals : Data presented in Table 4.6 indicated that foliar sprays of cycocel, thiourea and succinic acid produced significantly higher straw yield by 8.73, 9.06 and 6.60 per cent, respectively over control (water spray). However, agrochemicals were found at par in this respect.

4.3.3 Biological Yield :

Varieties : It is clear from data (Table 4.6) that *durum* variety HI8498 produced significantly the highest biological yield of 89.83 q ha^{-1} which was higher by 10.07, 10.08 and 26.73 per cent over Lok-1, HW2004 and A 9-30-1, respectively. Further, *aestivum* varieties HW2004 and Lok-1 were found at par in this respect, but produced significantly higher biological yield by 15.12 and 15.13 per cent, respectively over *durum* check variety A 9-30-1.

Agrochemicals : Foliar sprays of cycocel, thiourea and succinic acid produced significantly higher biological yield by 16.69, 13.45 and 9.47 per cent, respectively, over water spray (Table 4.6). The maximum biological yield of 86.18 q ha^{-1} was obtained with foliar spray of cycocel, which was significantly higher over succinic acid but was found at par with thiourea. Further, foliar spray of thiourea was also found at par with succinic acid in this respect.

4.3.4 Harvest Index :

Varieties : Data (Table 4.6) show that *aestivum* variety HW2004 recorded significantly higher harvest index over check variety Lok-1. Further, *durum* variety HI8498 gave significantly higher harvest index over *aestivum* check variety Lok-1 but was found at par with *durum* check variety A 9-30-1.

Agrochemicals : Foliar spray of cycocel recorded significantly the highest harvest index of 43.10 per cent. Foliar spray of thiourea gave significantly higher harvest index over foliar spray of succinic acid and control (water spray), while foliar spray of succinic acid was found at par with water spray in this respect.

4.4 EFFECT OF VARIETIES AND AGROCHEMICALS ON NITROGEN CONTENT AND UPTAKE AND PROTEIN CONTENT :

Effect of various treatments on nitrogen content and uptake by the crop at harvest and protein content in grain are presented in Table 4.7 and their analysis of variance in Appendix-VII.

4.4.1 Nitrogen Content in Grain :

Varieties : Data (Table 4.7) indicate that *aestivum* varieties were observed at par in respect of N content in grain. However, *durum* variety HI8498 recorded significantly the highest N content in grain (2.005%).

Table 4.7 Effect of varieties and agrochemicals on nitrogen content, uptake and protein content

Treatments	Nitrogen content (%)		Nitrogen uptake (kg ha^{-1})		Protein content in grain (%)
	Grain	Straw	Grain	Straw	
Varieties :					
Lok-1	1.942	0.534	62.24	26.56	12.14
HW2004	1.907	0.529	65.43	25.09	11.92
HI8498	2.005	0.547	74.99	28.79	12.53
A 9-30-1	1.877	0.516	54.64	21.67	11.73
SEm±	0.020	0.005	1.339	0.573	0.129
CD at 5%	0.059	0.015	3.867	1.655	0.372
Agrochemicals :					
Water spray	1.827	0.499	52.60	22.59	11.42
Cycocel	1.998	0.549	74.33	26.99	12.49
Thiourea	1.946	0.536	67.51	26.43	12.16
Succinic acid	1.959	0.542	62.85	26.09	12.24
SEm±	0.020	0.005	1.339	0.573	0.129
CD at 5%	0.059	0.015	3.867	1.655	0.372

Agrochemicals : Foliar spray of cycocel, thiourea and succinic acid recorded significantly higher N content in grain over water spray (Table 4.7).

4.4.2 Nitrogen Content in Straw :

Varieties : Data (Table 4.7) show that *durum* variety HI8498 had significantly the highest N content in straw and was closely followed by *aestivum* variety Lok-1.

Agrochemicals : Foliar sprays of cycocel, thiourea and succinic acid were observed at par in respect of N content in straw and all these agrochemicals recorded significantly higher N content in straw over control (water spray).

4.4.3 Nitrogen Uptake by Grain :

Varieties : Data (Table 4.7) show that *durum* variety HI8498 gave significantly the highest N uptake by grain. While *aestivum* varieties namely, Lok-1 and HW2004 were observed at par in this respect.

Agrochemicals : Data presented in Table 4.7 show that foliar spray of cycocel gave significantly the highest N uptake of 74.33 kg ha^{-1}. Further, foliar spray of thiourea recorded significantly higher N uptake by grain over succinic acid and water spray. Foliar spray of succinic acid also showed higher N uptake by grain over control (water spray).

4.4.4 Nitrogen Uptake by Straw :

Varieties : It is evident from data (Table 4.7) that *durum* variety HI8498 gave significantly the highest N uptake by straw. While, *aestivum* variety HW2004 was observed at par with check variety Lok-1 in this respect.

Agrochemicals : Data presented in Table 4.7 show that foliar

FIG.4.2 EFFECT OF VARIETIES AND AGROCHEMIALS ON MOISTURE DEPLETION PATTERN BY WHEAT VARIETIES UNDER FOLIAR SPRAY OF DIFFERENT AGRO-CHEMICALS (WATER USE IN mm FROM SOIL PROFILE)

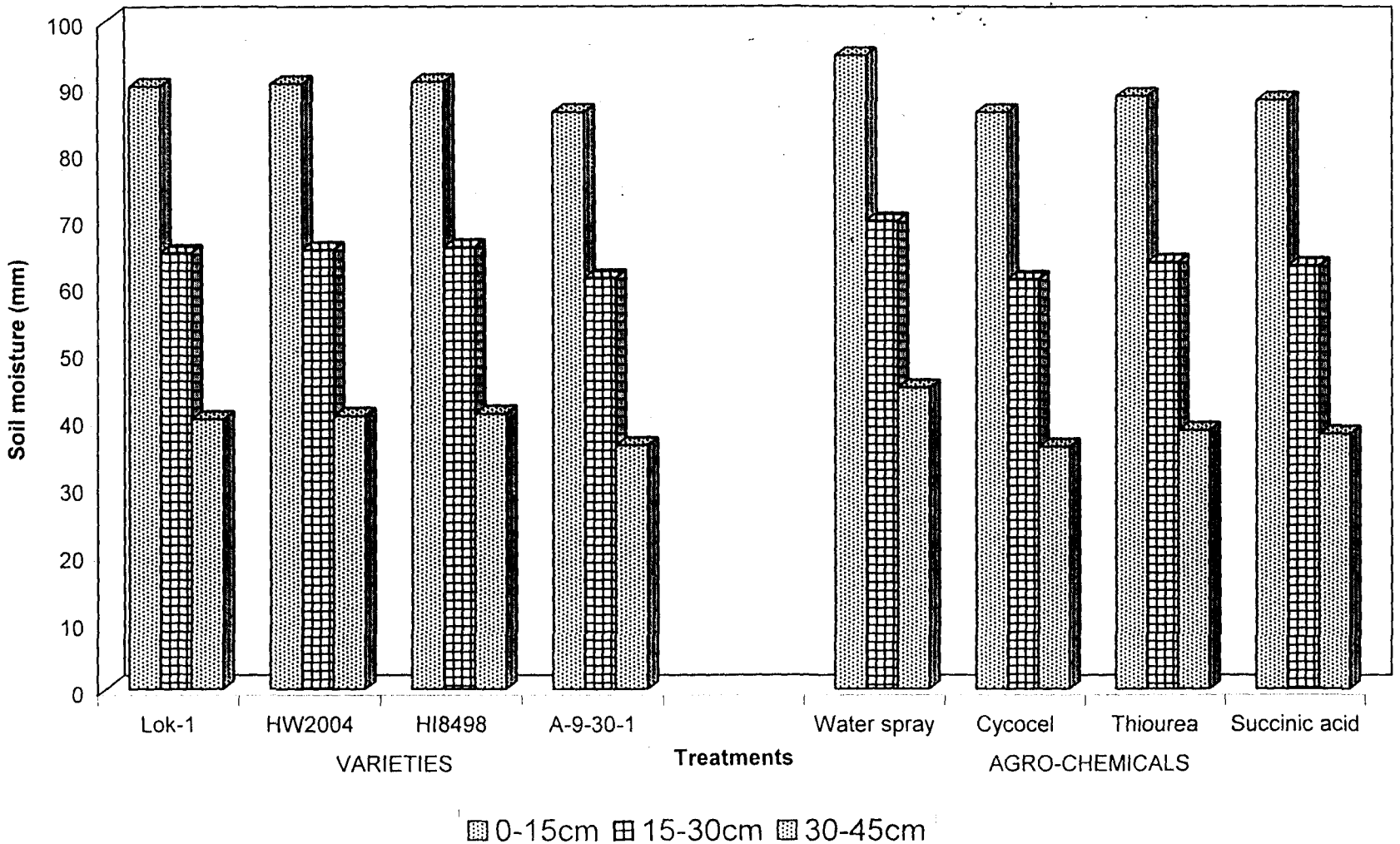


Table 4.8 Effect of varieties and agrochemicals on consumptive water use and water use eficiency

Treatments	Consumptive water use (mm)	Water use efficiency (kg grain ha^{-1} mm^{-1})
Varieties :		
Lok-1	195.11	16.55
HW2004	196.42	17.58
HI8498	197.43	19.13
A 9-30-1	190.24	15.44
SEm±	4.547	0.553
CD at 5%	NS	1.597
Agrochemicals :		
Water spray	209.30	13.80
Cycocel	183.45	20.32
Thiourea	190.79	18.15
Succinic acid	195.70	16.43
SEm±	4.547	0.553
CD at 5%	13.132	1.597

spray of cycocel, thiourea and succinic acid were observed at par in respect of N uptake by straw and all these agrochemicals gave significantly higher N uptake by straw over control (water spray).

4.4.5 Protein Content in Grain :

Varieties : A perusal of data (Table 4.7) reveals that *durum* variety HI8498 recorded significantly the highest protein in grain. While, *aestivum* varieties were found at par in this respect.

Agrochemicals : All the agrochemicals gave significantly higher protein in grain over control (water spray).

4.5 MOISTURE EXTRACTION PATTERN, CONSUMPTIVE WATER USE AND WATER USE EFFICIENCY

Moisture extraction pattern by wheat varieties under foliar spray of different agrochemicals were studied upto depth of 45cm. The moisture depletion patterns are depicted in Fig.4.2.

Data on consumptive water use (mm) and water use efficiency (kg grain ha^{-1} mm^{-1}) are presented in Table 4.8 and their analysis of variance in Appendix-VIII.

4.5.1 Soil Moisture Change and Moisture Use Pattern :

Irrespective of varieties and agrochemicals the maximum depletion was recorded from 0-15cm soil layer. The moisture depletion decreased gradually with increase in depth and thus lowest depletion was from 30-45cm soil layer.

4.5.2 Consumptive Water Use :

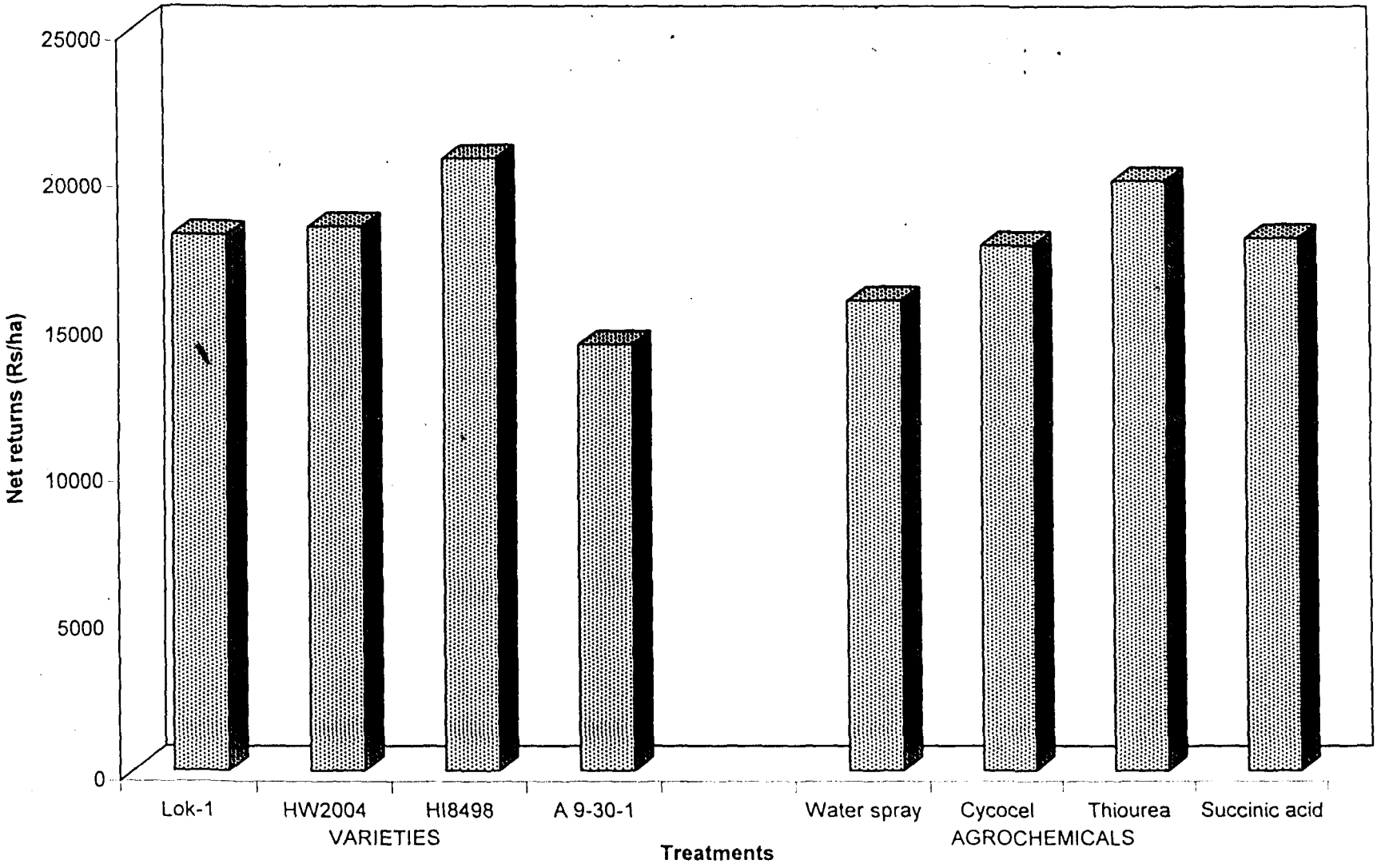
Varieties : Data (Table 4.8) show that varieties did not significantly influence consumptive water use by the crop.

Agrochemicals : It is evident from data (Table 4.8) that foliar

Table 4.9 Effect of varieties and agrochemicals on net returns and B:C ratio

Treatments	Net returns (Rs ha^{-1})	B:C ratio
Varieties :		
Lok-1	18070.00	2.06
HW2004	18351.00	2.11
HI8498	20677.00	2:33
A 9-30-1	14338.00	1.65
SEm±	496.5	0.0592
CD at 5%	1434.1	0.1711
Agrochemicals :		
Water spray	15857.00	2.01
Cycocel	17717.00	1.47
Thiourea	19896.00	2.47
Succinic acid	17967.00	2.21
SEm±	496.5	0.0592
CD at 5%	1434.1	0.1711

FIG.4.2 EFFECT OF VARIETIES AND AGROCHEMICALS ON NET RETURNS



spray of cycocel recorded the lowest consumptive water use (183.45mm) which was significantly lower than that obtained in control (water spray) and at par with foliar spray of thiourea and succinic acid. Foliar spray of thiourea and succinic acid were observed at par in this respect. However, these treatments recorded slightly lower consumptive water use as compared to water spray.

4.5.3 Water Use Efficiency :

Varieties : It is evident from data presented in Table 4.8 that *durum* variety HI8498 recorded the highest water use efficiency of 19.13 kg grain ha^{-1} mm^{-1} and was closely followed by *aestivum* variety HW2004. Further, *aestivum* varieties namely, HW2004 and Lok-1 were found at par in this respect.

Agrochemicals : Data presented in Table 4.8 show that foliar spray of cycocel gave significantly the highest water use efficiency of 20.32 kg grain ha^{-1} mm^{-1} water. Foliar spray of thiourea gave significantly higher water use efficiency over succinic acid and water spray. Foliar spray of succinic acid also recorded significantly higher water use efficiency over water spray.

4.6 ECONOMIC EVALUATION OF TREATMENTS :

The details of cost of cultivation of the crop including treatment application and gross returns and B:C ratio are given in Appendices-X and XI. Statistically analysed data on net returns under the influence of varieties and agrochemicals are presented in Table 4.9.

4.6.1 Net Returns :

Varieties : Data (Table 4.9) explicitly show that *durum* variety HI8498 gave significantly the highest net returns of Rs.20677 ha^{-1} which was higher by 12.67, 14.42 and 44.21 per cent over HW2004, Lok-1 and A 9-30-1, respectively.

Agrochemicals : It is evident from the data (Table 4.9) that foliar spray of thiourea at 1000ppm recorded significntly the highest net returns of Rs.19896 ha^{-1} which was higher by 12.29, 10.73 and 25.47 per cent over thiourea, succinic acid and water spray (control), respectively.

4.6.2 B:C Ratio :

Varieties : Data (Table 4.9) show that *durum* variety HI8498 gave significantly the highest B:C ratio of 2.33. Further, *aestivum* varieties Lok-1 and HW2004 were observed at par in this respect and both these varieties recorded significantly higher B:C ratio over *durum* check variety A 9-30-1.

Agrochemicals : Data presented in Table 4.9 show that foliar spray of thiourea gave significantly the highest B:C ratio of 2.47. While, foliar spray of cycocel recorded significantly the lowest B:C ratio of 1.47. Foliar spray of succinic acid also gave significantly higher B:C ratio by 9.95 per cent over water spray.

5. DISCUSSION

During the course of presenting the results of the experiment entitled "Effect of Agrochemicals on Growth, Yield and Quality of *aestivuun* and *durum* Wheat Varieties Under Limited Iirrigation Conditions" significant variations were noted in number of criteria studied for treatment evaluation. In this chapter, an attempt is being made to discuss the significant findings obtained and reconcile them into some tangible concept in order to explain the treatment differences for the growth and productivity of the test crop. Wherever felt necessary, experimental findings of other workers have been cited to support the results of the present investigation. The entire discussion has been confined to a few pertinent headings.

5.1 EFFECT OF VARIETIES:

5.1.1 Growth Characters :

In the present investigation, significant varietal differences in respect of growth characters of wheat under limited irrigation conditions were observed (Table 4.1 to 4.3). The *durum* wheat variety HI8498 produced significantly the highest number of total tillers (except HW2004) at the maximum tillering stage and dry matter at successive growth stages. While, *aestivum* variety HW2004 recorded significantly the highest plant height and the variety Lok-1 gave the maximum CGR and RGR observed between tillering and anthesis.

Significantly the highest number of tillers m^{-1} row length in respect of the *durum* variety HI8498 could be attributed to higher content and uptake of nitrogen by the variety (Table 4.7) which might have resulted in higher LAI. Jat (1995) obtained the higher LAI in HI8498 among three *aestivum* and *durum* test varieties. Significant and positive correlation between nitrogen content in grain (r=0.855**) and number of tillers at maximum tillering stage also support the afore said contention. Thus, probably higher

LAI in the variety HI8498 might have resulted in better photosynthesis and accumulation of photosynthates. Further, a part of photosynthates so accumulated might have been utilized in the production of greater number of tillers (Swami, 1999).

The variety HI8498 produced significantly the highest dry matter at the successive crop growth stages. The over all vigorous growth of the crop plants due to better LAI and subsequently tillering might be accounted for the maximum dry matter accumulation by the variety (Jat, 1995). Significant and positive correlation (r=0.712**) between dry matter accumulation and total number of tillers at maximum tillering stage also lends support to the above contention In contrast, the *aestivum* variety HW2004 recorded significantly the highest plant height, which appears to be the expression of inherent varietal characteristics. Similarly, the differential behaviours of the varieties with respect to days required to reach the various phenological phases could also be ascribed solely to their genetic make up. Bishnoi and Taneja (1990) also gave similar contentions.

5.1.2 Yield Attributes and Yield :

The results showed significantly higher number of effective tillers m^{-1} row length in the varieties HI8498 and HW2004 over check varieties Lok-1 and A 9-30-1, which might be due to better survival of tillers as a result of improvement in the crop growth at successive stages as reflected by significant increase in dry matter accumulation (Table 4.2). This contention also subscribes to the view that there was adequate supply of metabolites in the varieties HI8498 and HW2004 compared with rest of the varieties for growth and development of tillers. Significant and positive correlation (r=0.971**) between biomass at harvest and number of effective tillers also validate that higher accumulation of dry matter by the varieties HI8498 and HW2004 resulted in greater formation of effective tillers. Length of ear was greater in the variety Lok-1 (Table 4.5) while grains per ear were more in the varieties

HI8498 and HW2004 indicating compact ear and lax in Lok-1. Similarly, grain weight per ear and 1000-grain weight were also higher in the varieties HI8498 and HW2004, probably due to efficient translocation of metabolites towards grain formation. Further, the highest 1000-grain weight in the variety HI8498 suggest its genetic superiority for better sink and efficiency for its filling. These results are in close conformity with the findings of DWR (1998).

Variations in yield components among wheat varieties under the study were ultimately reflected in crop yields. The variety HI8498 *(durum)* produced significantly the highest grain yield of 37.33 q ha^{-1} under limited irrigation conditions (Table 4.6 and Fig.4.1) Thus, higher grain yield of HI8498 could be ascribed to cumulative effects of yield attributing characters, viz., higher effective tillers m^{-1} row length, more grains per ear and higher grain weight per ear as well as 1000-grain weight (DWR, 1999). The positive and significant correlations between grain yield and effective tillers m^{-1} row length (r=0.975**), grain weight per ear (r=0.953**) as well as 1000-grain weight (r=0.923**) also revealed dependence of the yield on yield attributes The variety HI8498 produced significantly the highest straw yield (Table 4.6). Significant differences in straw yield might be ascribed to more tillers m^{-1} row length, higher dry matter accumulation at harvest and indirectly by plant height and stem thickness. Similarly, the variety HI8498 also produced significantly the highest biological yield of 89.83 q ha^{-1} followed by Lok-1, HW2004 and A 9-30-1. Since biological yield is the sum of grain and straw yield produced by the crop, higher grain yield along with higher straw yield resulted in higher biological yield by the variety HI8498. Harvest index of the varieties HI8498, HW2004 and A 9-30-1 remained unaffected indicating thereby that efficiency of partitioning of photosynthates into grain and straw of all three varieties was parallel. However, harvest index was higher in the variety HW2004 indicating the efficiency

of partitioning of photosynthates into grain was more than straw. The marked variation in yield components and yield potential between *aestivums* and *durums* as well as among *aestivums* and *durums* were also observed by several research worker (Girothia *et al.*, 1987; Buldak, 1994; Jat, 1995; Mishra *et al.*, 2000).

5.1.3 Nutrient Content, Uptake and Grain Quality :

The results revealed that grains and straw of the *durum* variety HI8498 had the highest N content at harvest followed by Lok-1, HW2004 and A 9-30-1. Varietal variations in uptake of N were also exhibited by grain and straw. The variety HI8498 also showed significantly the highest uptake of N by grain and straw followed by Lok-1, HW2004 and A 9-30-1 (Table 4.7). The higher N content in grains and straw of HI8498 and Lok-1 at harvest might be due to their greater capabilities for efficient absorption, utilization and translocation of nitrogen. Further, the highest uptake of nitrogen seems to be on account of its higher concentration in grains as well as straw and increased grain and straw yield. Significant and positive correlation (r=0.982**) between grain yield and total uptake of N by the crop also support the above contention. The results of present investigation indicated differential behaviours of wheat varieties with respect to nutrient content and their uptake are in close conformity with findings of Buldak (1994), Jat (1995) and Kulhari (1999).

The highest protein content in grain was recorded with variety HI8498 followed by Lok-1, HW2004 and A 9-30-1 (Table 4.7) This could be ascribed to better inherent capacity of the variety HI8498 in absorption, translocation and utilization of nitrogen. Swami (1999) also observed the highest protein content by the variety HI8498.

5.1.4. Consumptive Water Use and Water Use Efficiency:

The results indicated that water use efficiency of *durum*

variety HI8498 was the highest among all the varieties followed by HW2004, Lok-1 and A 9-30-1.

5.2 EFFECT OF AGROCHEMICALS :

5.2.1. Cycocel :

5.2.1.1 Growth character :

Foliar spray of cycocel at 1000 ppm gave significantly the lowest plant height at harvest. While, it produced significantly the highest dry matter at anthesis as well as at harvest and CGR and RGR recorded between tillering and anthesis stages (Table 4.1 to 4.3). The decrease in plant height due to application of cycocel might be due to the fact that cycocel is an antigibberellin compound and when applied, it might have negated the endogenous gibberellic acid quantity. Therefore, activities like apical growth, cell elongation and cell growth might have been inhibited, resulting in reduced plant height. These results are in close conformity with the findings of various researchers like Cathey (1964) , who reported that cycocel significantly reduced plant height due to inhibition of cell division in the sub-apical meristematic zone of stem, responsible for internode elongation. The explanation for increase in dry matter accumulatiom m^{-1} row length with the application of cycocel lends the support from earlier discussion on plant height, where it has significantly decreased the plant height (Table 4.1). The decrease in plant height has always been associated with the increase in stem diameter and consequently increase in dry matter, because lesser the height, thicker the stem and *vice versa.* Secondly, cycocel by virtue of reducing the size of vessels and sieve tubes and delaying lignification might have increased cell wall thickness. This might have led to increase in the stem diameter and consequently the dry matter accumulation.

Further, the increase in dry matter accumulation might be due to the fact that CCC promotes root/shoot ratio which favourably influence the uptake of water and nutrients (Krishnamoorthy, 1993).

5.2.1.2 Yield attributes and yield :

The results indicated that one foliar spray of CCC brought about significant increases in number of effective tillers m^{-1} row length, ear length, number of grains per ear, grain weight per ear and 1000- grain weight over water spray (Table 4.5). The increases in the above yield attributes with the foliar spray of cycocel at 1000 ppm might be due to the suppressing effect of CCC on plant height (Table 4.1), which in turn resulted in ceasing of the terminal growth. Ultimately, the available auxin might have been used for the promotion of the number of effective tillers, grains per ear, grain weight per ear and 1000-grain weight (Kolev and Terzeiv, 1996). Further, because of reduction in plant height with the application of CCC, lodging of the crop was also probably reduced. Thus, more solar radiation was available to the lower parts of plant which ultimately helped in increasing the rate of photosynthesis in plant. Consequently more quantity of synthesized food material was available for translocation for the formation of more effective tillers which resulted in higher number of grains per ear and grain weight per ear. These results are in cognizance with the findings of Myhre *et al.* (1973) and Kolev and Terziev (1996). The results indicated that the foliar spray of cycocel at 1000 ppm at maximum tillering stage of the crop recorded significantly the highest grain yield of 37.14 q ha^{-1} (Table 4.6 and Fig.4.1). This increase in grain yield of wheat due to the application of cycocel apparently seems to be associated with significant increases in dry matter accumulation at anthesis and at harvest, effective tillers m^{-1} row length, grains per ear, grain weight per ear and 1000- grain weight as well as retention of leaves for a longer period. CCC treatment increased root growth at all depths that

enabled the crop to tap larger volume of soil moisture from deeper layers. Several workers have reported beneficial effect of cycocel on relative leaf water content in many crops like cotton (Durdyev, 1972). Increase in relative leaf water content and leaf water potential leads to an over all improvement in photosynthesis and other metabolic processes in plant that result in better growth and yield. The results demonstrate amply well the functional role of CCC in physiological system of plants. The main functional role of CCC is in regulating the allocation of photosynthates for various growth purposes. In the present investigation, the excessive diversion of photosynthates for elongation of stem was arrested as evident from the decreased plant height. The decrease in sink power of the culm might also partly explain the higher yield recorded in this treatment due to increase in transportation of assimilates to ears for formation of more grains per ear which ultimately resulted in increased grain yield (Pinthus and Rudich, 1967; Phil-Potts, 1972). Significant and positive correlation between grain yield and number of effective tillers m^{-1} row length ($r=0.975^{**}$), grain weight per ear ($r=0.953^{**}$), 1000-grain weight ($r= 0.923^{**}$) and dry matter at harvest ($r=0.981^{**}$) also support the above contention. Foliar spray of cycocel at 1000 ppm also brought about significant increases in straw and biological yield over water spray (Table 4.6). The increase in straw yield could be ascribed to higher number of effective tillers m^{-1} row length and increase in dry matter at harvest, which in turn led to increase in straw yield. Similar findings were also observed by Sajo and Kabura (1998). Significant and positive correlations between straw yield and effective tillers ($r=0.764^{**}$) as well as dry matter accumulation at harvest ($r=0.827^{**}$) also support the aforesaid contention. The results further indicated that foliar spray of CCC recorded significantly the highest harvest index (Table 4.6). This increase could be ascribed on account of higher efficiency of CCC in partitioning of photosynthates into grain instead of straw (Srivastava, 1968).

5.2.1.3 Nutrient content, uptake and grain quality :

Foliar spray of cycocel significantly increased nitrogen content in grain and straw (Table 4.7). This seems to be on account of increased mobilization of nutrients from various plant parts to sink as evinced from their increased content in grain and straw. Significantly higher uptake of nutrients by grain and straw seems to be due to balanced environment, increased mobilization and translocation of nutrients as well as increased grain and straw yield. The increased uptake of N seems to be on account of cumulative effects of increased nutrient content and higher grain and straw yield. These results are in close agreement with the findings of Cheema *et al.* (1982) and Kandalam and Giri (1999).

Results further indicated that foliar spray of CCC at 1000 ppm significantly increased protein content in grains (Table 4.7) This could be attributed to increase in N content and N uptake by the crop due to spray of CCC. Several workers also observed increase in protein content in grain with foliar spray of CCC (Gendy, 1994 and Ma *et al.*, 1994).

5.2.1.4 Consumptive water use and water use efficiency :

The results indicated that foliar spray of CCC at 1000 ppm significantly reduced consumptive water use, while significantly increased water use efficiency (Table 4.8) In the present experiment, foliar spray of CCC brought about significant reduction in vegetative growth in terms of plant height and probably leaf area there by minimizing water loss through transpiration and metabolic activities which manifested its antitranspirant properties. The reason for reduction in water use with CCC could be further attributed to decrease in water uptake by the application of CCC (Gohlker and Tolbert, 1962). Cycocel was also found conducive for inducing significantly lower water use with higher grain yield which ultimately resulted in higher water use efificiency. These results are also similar to those of Srivastava and Bansal (1975).

5.2.2 Thiourea :

5.2.2.1 Growth characters :

The results indicated that one foliar spray of thiourea at 1000ppm at maximum tillering stage of the crop recorded significant increases in plant height at harvest, dry matter accumulation at anthesis and at harvest as well as CGR recorded between tillering and anthesis in comparison to water spray (Table 4.1 to 4.3).

The increase in plant height with the application of thiourea might be due to the fact that it promotes the vegetative growth by way of active cell division and cell elongation. Another reason for the increase in plant height might be the increased osmotic uptake of water and nutrients under the influence of thiourea, which might have maintained a constant swelling force against softening of cell walls and thereby the plant height might have increased. Further, the beneficial effects could be on account of formation of -SH compound by thiourea and its cytokinin like activities, thereby increasing plant height (Jocelyn, 1972). These results are in agreement with the findings of Mahavar (1989) who reported that foliar spray of 0.2 per cent thiourea on mustard significantly increased dry matter production per plant and plant height over control. The increase in dry matter accumulation with the application of thiourea could be attributed to an increase in the plant height as a result of cell elongation and cell enlargement, consequently plants might have produced longer and thicker stems and hence, the dry matter accumulation might have increased. Significant and positive correlation ($r=0.825^{**}$) between plant height and dry matter accumulation at harvest also lends support to the aforesaid contention. These results are in close conformity with the findings of Sharma (1988).

5.2.2.2 Yield attributes and yield :

The results indicated that one foliar spray of thiourea

at 1000ppm significantly increased number of effective tillers m^{-1} row length, ear length, grains per ear, grain weight per ear and 1000-grain weight as compared with water spray (Table 4.5). Increases in these parameters seems to be due to the vigorous vegetative growth of plants (Table 4.1) which ultimately resulted in more leaf area and increased photosynthesis, thereby formation of higher number of effective tillers m^{-1} row length, grains per ear, grain weight per ear and 1000-grain weight as well as greater ear length. These results are in accordance with the findings of Sahu and Singh (1995) who observed significant increases in number of ears, grains per ear and 1000-grain weight over water spray in wheat. The results further showed that one foliar spray of thiourea at 1000ppm recorded significant increase in grain yield over water spray (Table 4.6 and Fig.4.1).

Grain yield is chiefly a product of yield attributing characters viz., number of effective tillers m^{-1} row length, number of grains per ear, grain weight per ear and 1000-grain weight. The increase in these characters might have increased grain yield of wheat. The increases in different growth and yield attributing characters along with yield due to application of thiourea at 1000ppm appears to be a function of greater photosynthetic efficiency, maintenance of its higher rate for longer duration and production as well as accumulation of more photosynthates per unit leaf area, which in turn led to increased vegetative growth and finally to greater accumulation and translocation of photosynthates towards sink. Thus, the increased accumulation of photosynthates in growing grains probably prolonged the filling process and ultimately led to higher grain yield. These results are in close conformity with the findings of Sahu and Solanki (1991), who reported higher maize productivity probably on account of increased photosynthates transport as evident by improved dry matter partitioning with the application of thiourea. Significant and positive correlation between grain yield and number of effective tillers ($r=0.975^{**}$), grain weight

per ear (r=0.953**), 1000-grain weight (r=0.923**) and dry matter production at harvest (r=0.981**) also support the above contention.

The results indicated that one foliar spray of thiourea at 1000ppm at maximum tillering stage brought about significant increase in straw as well as biological yield and harvest index compared with water spray (Table 4.6). The increase in straw yield with the application of thiourea seems to be on account of increase in plant height and dry matter accumulation at harvest. Significant and positive correlations between straw yield and dry matter accumulation at harvest (r=0.827**) as well as plant height at harvest (r=0.977**) also support the above contention. These results are in close conformity with the findings of Parihar (1998).

The increase in biological yield could be ascribed to significant increase in grain and straw yield, which in turn led to higher biological yield (Parihar *et al.*, 1998). The increase in harvest index could be attributed to increase in grain yield in proportion to straw yield. Similar findings were also observed by Sharma (1988).

5.2.2.3 Nutrient content, uptake and grain quality :

Foliar spray of thiourea at 1000ppm significantly increased N content in grain and straw, N uptake by grain and straw and protein content in grain as compared to water spray (Table 4.7). These increases seem to be on account of increased mobilization of nutrients from various plant parts including leaves to grains. These findings are in accordance with those of Mahavar (1989) and Sachan (1991). The uptake of nutrient is primarily a function of total biomass production and secondly of nutrient content at the cellular level. Thus, marked increase in uptake of N following the application of thiourea in the present investigation mainly appears to be due to increased dry matter production at harvest which resulted due to increased photosynthetic efficiency. These results are in conformity with the findings of Parihar (1994). The

increase in protein content in grain could be ascribed to increase in N content and N uptake by the crop due to spray of thiourea. Significant and positive correlation (r=0.623**) between N uptake by grain and protein content in grain also support these contentions. These results are in close agreement with the findings of Verma (1988).

5.2.2.4 Consumptive water use and water use efficiency :

The results indicated that foliar spray of thiourea at 1000ppm gave significantly higher water use efficiency over water spray (Table 4.8). This increase in water use efficiency could be attributed to increase in grain yield due to increased dry matter production from unit quantity of water used by the crop (Sahu and Singh, 1995).

5.2.3 Succinic Acid :

5.2.3.1 Growth characters :

The results showed that one foliar spray of succinic acid at 1000ppm at maximum tillering stage of the crop brought about significant increases in growth parameters *viz.*, total dry matter at anthesis and at harvest (Table 4.2). Studies have indicated that foliar spray of succinic acid tended to significantly improve the growth parameters. Succinic acid may get converted to succinic semi-aldehyde which in turn may be aminated by γ-aminobutyric acid transminase to γ-aminobutyric acid (GABA) which plays an important role in stress mitigation and growth promotion. Succinic acid may also get converted to succinyl co-enzyme by the enzyme succinyl thiokinase which reacts with glycine to form δ-aminolevulinic acid. δ-aminolenulinic acid is a precursor of porphyrins which may incorporate iron to form haeme which is component of haematinic enzyme, catalase and peroxidase as well as cytochromes (important components of electron transport chain in both mitochondria and chloroplasts). Porphyrins may alternatively incorporate Mg to form

chlorophyll. Thus both photosynthesis and respiration may be improved by succinic acid (Devlin and Witham, 1986).

5.2.3.2 Yield attributes and yield :

The results indicated that one foliar spray of succinic acid at 1000 ppm recorded significant increases in yield attributes viz., effective tillers m^{-1} row length, grain weight per ear, 1000-grain weight and yield *viz.*, grain, straw and biological (Table 4.5 and 4.6) over water spray. Increase in N content and uptake might have resulted in significant increases in growth and yield parameters, which ultimately led to increases in grain and straw yield (Mikhailova *et al.*, 1997). Significant and positive correlation between grain yield and dry matter at harvest (r=0.981**), effective tillers m^{-1} row length at harvest (r=0.975**), grain weight per ear (r=0.953**) and 1000-grain weight (r=0.923**) also support increase in grain yield with the application of succinic acid.

5.2.3.3 Nutrient content, uptake and grain quality :

Foliar spray of succinic acid also increased N content as well as uptake by grain and straw as compared with water spray (Table 4.7). The increased uptake of N seems to be on account of cumulative effects of increased nutrient content and higher grain and straw yield. The results further indicated that foliar spray of succinic acid significantly increased protein content in grain over water spray (Table 4.7). This could be attributed to increase in N content and uptake by the crop with the application of succinic acid. Similar results were also reported by Kirillova (1973).

5.2.3.4 Consumptive water use and water use efficiency :

Due to the foliar applied succinic acid water use efficiency of the crop significantly increased over control (Table 4.8). This increase in WUE could be ascribed to increased dry matter at harvest from a unit quantity of water used by the crop when treated with succinic acid as reflected by significant increase in grain yield (Table 4.6).

Table 5.1 Correlation coefficient and regression equations showing relationship between independent variables (X) and depdendent variables (Y)

S. No.	Dependent variables (Y)	Independent variables (X)	Correlation coefficient (r)	Regression equation (Y = a + bX)
1.	Total tillers at maximum tillering	DMA at maximum tillering	0.712**	Y = -19.199 + 2.518X
2.	Dry matter at harvest	Plant height	0.825**	Y = 7.67 + 7.763X
3.	Effective tillers at harvest	DMA at harvest	0.971	Y = -44.765 + 0.765X
4.	Grain yield	Total tillers at maximum tillering	0.789**	Y = -42.875 + 0.441X
5.	Grain yield	Effective tillers at harvest	0.975**	Y = -10.057 + 0.361X
6.	Grian yield	Grain weight per ear	0.953**	Y = -44.851 + 42.624X
7.	Grain yield	1000-grain weight	0.923**	Y = -33.993+1.494X
8.	Grain yield	Total N uptake	0.982**	Y = -24.833 + 0.365X
9.	Grain yield	DMA at harvest	0.981**	Y = -28.336 + 0.286X
10.	Straw yield	Total tillers at maximum tillering	0.722**	Y = -19.551 + 0.391X
11.	Straw yield	Effective tillers at harvest	0.764**	Y = 15.091 + 0.274X
12.	Straw yield	Plant heigh at harvest	0.977**	Y = -42.232 + 1.631X
13.	Straw yield	DMA at harvest	0.827**	Y = -2.34 + 0.233X
14.	Protein content in grain	N uptake by grain	0.623**	Y = 22.913 + 1.606X
15.	Total N uptake by the crop	Grain yield	0.982**	Y = -11.789 + 3.068X
16.	Total N uptake by the crop	Straw yield	0.876**	Y = -14.454 + 2.827X

6. SUMMARY

A field experiment entitled "Effect of Agrochemicals on Growth, Yield and Quality of *aestivum* and *durum* Wheat Varieties Under Limited Irrigation Conditions" was conducted at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur during *rabi* 2000-2001. The findings presented and discussed in the preceding chapters are being summarized as under :

6.1 EFFECT OF VARIETIES :

6.1.1 Growth and Development :

Varieties did not significantly influence germination count recorded at 10 DAS. Significantly the highest number of total tillers m^{-1} row length were recorded with *durum* variety HI8498 except *aestivum* variety HW2004. Variety HW2004 recorded significantly the highest plant height at harvest. Variety HI8498 (*durum*) accumulated significantly the highest dry matter at maximum tillering, anthesis and at harvest stages of the crop, while variety HW2004 (*aestivum*) accumulated significantly higher dry matter over check variety Lok-1 at anthesis only. Check variety Lok-1 recorded the maximum values of CGR and RGR during vegetative phase (tillering-anthesis). Varieties did not significantly influence days to germination. Variety HW2004 took significantly greater number of days to attain successive phenological stages *viz.*, tillering initiation, booting, heading and maturity as compared to *aestivum* check variety Lok-1. Whereas, *durum* variety HI8498 took significantly lesser number of days to attain various phenological stages compared with check variety A 9-30-1.

6.1.2 Yield Attributes :

Varieties HI8498 and HW2004 produced significantly higher effective tillers m^{-1} row length and grains per ear compared with check varieties Lok-1 and A 9-30-1. Both *aestivum* varieties recorded

significantly greater length of ear in comparison to *durum* varieties viz., A 9-30-1 and HI8498. The former varieties were observed at par in this respect. Varieties HI8498, HW2004 and Lok-1 gave significantly higher grain weight per ear over A 9-30-1. Further, *durum* variety HI8498 recorded significantly the highest 1000-grain weight.

6.1.3 Yield and Quality Parameters :

Variety HI8498 (*durum*) produced significantly the highest grain yield (33.37 q ha^{-1}) which was higher by 9.12, 16.83 and 28.63 per cent over HW2004, Lok-1 and A 9-30-1, respectively. Variety HI8498 also produced significantly the highest straw and biological yields. Varieties HW2004, HI8498 and A 9-30-1 were observed at par in respect of harvest index, but all these varieties recorded significantly higher harvest index over Lok-1. Variety HI8498 (*durum*) recorded significantly the highest nitrogen content in grain as well as straw and protein content in grain and nitrogen uptake by grain as well as straw.

6.1.4 Consumptive Water Use and Water Use Efficiency :

Varieties did not significantly influence consumptive water use. However, variety HI8498 recorded the highest water use efficiency.

6.1.5 Net Returns and B:C Ratio :

Among all the wheat varieties, *durum* variety HI8498 gave significantly the highest net returns of Rs 20677 and B:C ratio of 2.33.

6.2 EFFECT OF AGROCHEMICALS :

6.2.1 Growth and Development :

Foliar sprays of agrochemicals did not significantly influence germination count and total tillers m^{-1} row length. Foliar spray of CCC @ 1000ppm gave significantly the lowest plant height

recorded at harvest. In contrast, foliar spray of thiourea (1000ppm) gave significantly higher plant height at harvest over water spray and foliar spray of succinic acid was found at par with water spray in this respect. At anthesis, foliar spray of cycocel gave significantly the highest dry matter followed by foliar spray of thiourea and succinic acid. At harvest, foliar spray of CCC recorded significantly higher dry matter by 13.15, 2.54 and 5.93 per cent over water spray, thiourea and succinic acid sprays, respectively. Foliar spray of CCC gave significantly the highest values of CGR and RGR recorded between tillering and anthesis stages. Foliar sprays of agrochemicals failed to produce significant effect on various phenological stages of the crop.

6.2.2 Yield Attributes :

Cycocel at 1000ppm produced significantly the highest number of effective tillers m^{-1} row length. Foliar spray of cycocel and thiourea recorded significantly greater ear length and higher number of grains per ear over water spray. Foliar spray of cycocel at 1000ppm gave the highest grain weight per ear (1.88g) and test weight (46.25g) which were significantly higher over water spray.

6.2.3 Yield and Quality Parameters :

Cycocel, thiourea and succinic acid as foliar sprays resulted in 29.18, 20.34 and 11.37 per cent increases in grain yield compared with water spray. Foliar sprays of CCC, thiourea and succinic acid also produced significantly higher straw yield by 8.73, 9.06 and 6.60 per cent over control (water spray), respectively. Cycocel at 1000ppm produced the maximum biological yield of 86.18 q ha^{-1} which was significantly higher by 16.69 per cent over water spray. Foliar spray of CCC recorded significantly the highest harvest index. Foliar spray of thiourea also recorded significantly higher harvest index over foliar spray of succinic acid and water spray.

Foliar sprays of cycocel, thiourea and succinic acid were observed at par in respect of N content in grain as well as straw and protein content in grain and all these agrochemicals were found significantly superior in respect of these parameters over water spray. Cycocel at 1000ppm recorded significantly the highest N uptake (74.33 kg ha^{-1}) by grain which was statistically superior over other agrochemicals. All the agrochemicals gave significantly higher N uptake by straw over water spray.

6.2.4 Consumptive Water Use and Water Use Efficiency :

Foliar sprays of cycocel, thiourea and succinic acid significantly reduced consumptive water use over control (water spray). Foliar spray of cycocel (1000ppm) at maximum tillering stage recorded significantly the highest WUE followed by foliar spray of thiourea and succinic acid.

6.2.5 Net Returns and B:C Ratio :

Among the agrochemicals, foliar spray of thiourea at 1000 ppm recorded significantly the highest net returns of Rs 19896 ha^{-1} and B:C ratio of 2.47.

CONCLUSION :

From the results of one year's field experimentation it may be concluded that *durum* wheat variety HI8498 appears to be the best suited variety under limited irrigation conditions as it recorded significantly the highest grain yield with the maximum water use efficiency. Among agrochemicals, foliar spray of cycocel at 1000ppm is the most effective treatment under limited irrigation conditions as it recorded significantly the highest grain yield with the lowest consumptive water use and maximum water use efficiency. However, due to prohibitive cost this treatment is not economically sound. Foliar spray of thiourea at 1000ppm appears to be economically viable treatment as it gave the maximum net returns and B:C ratio. These findings need further investigation for confirmation.

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ABSTRACT

EFFECT OF AGROCHEMICALS ON GROWTH, YIELD AND QUALITY OF *aestivum* AND *durum* WHEAT VARIETIES UNDER LIMITED IRRIGATION CONDITIONS

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A field experiment entitled "Effect of Agrochemicals on Growth, Yield and Quality of *aestivum* and *durum* Wheat Varieties Under Limited Irrigation Conditions" was conducted during *rabi*, 2000-2001 at the Instructional Farm, Department of Agronomy, Rajasthan College of Agriculture, Udaipur. The objectives of the experiment were : (i) to study the effect of agrochemicals on growth, yield and quality of wheat varieties. (ii) to select the best suited variety of wheat under limited irrigation conditions. (iii) to study the effect of agrochemicals on water use efficiency of wheat varieties.

The treatments consisted of four varieties (Lok-1, HW2004, HI8498 and A 9-30-1) and four foliar spray treatments (water spray, cycocel 1000ppm, thiourea 1000 ppm and succinic acid 1000 ppm) thereby making sixteen treatment combinations in all. The experiment was laid out in Randomized Block Design with three replications. The crop was sown on the 22nd November, 2000 and harvested on 20th April, 2001.

The results indicated that *durum* variety HI8498 produced significantly the highest number of total tillers at maximum tillering stage as well as dry matter at maximum tillering, anthesis and harvest stages. This variety also attained various phenological stages significantly earlier as compared with check variety A 9-30-1. However, *aestivum* check variety Lok-1 gave the maximum values of CGR and RGR recorded between tillering and anthesis. Varieties HI8498

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and HW2004 produced significantly higher effective tillers m^{-1} row length as well as grains per ear over varieties Lok-1 and A 9-30-1. Both *aestivum* varieties recorded significantly greater ear length in comparison to *durum* varieties A 9-30-1 and HI8498. Varieties HI8498, HW2004 and Lok-1 gave significantly higher grain weight per ear over A 9-30-1. Variety HI8498 (*durum*) recorded significantly the highest 1000-grain weight. Variety HI8498 (*durum*) produced significantly the highest grain yield (37.33 q ha^{-1}), straw yield (52.50 q ha^{-1}) and biological yield (89.83 q ha^{-1}) which were higher by 16.83, 5.71 and 10.07 per cent over Lok-1, 9.12, 10.80 and 10.08 per cent over HW2004 and 28.63, 25.41 and 26.73 per cent over A 9-30-1, respectively. Varieties HW2004, HI8498 and A 9-30-1 recorded significantly higher harvest index over Lok-1. Further, *durum* variety HI8498 recorded significantly the highest nitrogen content in grain and straw, protein content in grain and nitrogen uptake by grain as well as straw. HI8498 also recorded significantly the highest water use efficiency, net returns of Rs.20677 ha^{-1} and B:C ratio of 2.33.

The results indicated that foliar spray of cycocel at 1000ppm gave significantly the lowest plant height recorded at harvest. In contrast, foliar spray of thiourea at 1000ppm gave significantly higher plant height over water spray. Further, foliar sprays of agrochemicals recorded significant increases in dry matter accumulation at anthesis and at harvest. Foliar spray of cycocel gave significantly the highest values of CGR and RGR recorded between tillering and anthesis stages. Significant increases in yield attributes of the crop *viz.*, number of effective tillers, ear length, number of grains per ear, grain weight per ear and test weight were observed with foliar sprays of agrochemicals over water spray (control). Cycocel, thiourea and succinic acid as a foliar spray produced significantly higher grain yield by 29.18, 20.34 and 11.37 per cent over water spray, respectively. Foliar sprays of agrochemicals also gave significant increases in straw and biological yield, harvest

index, N content and uptake by grain as well as straw and protein content in grain over water spray. Application of agrochemicals significantly reduced consumptive water use as compared with water spray. While, all the agrochemicals gave significantly higher water use efficiency over control. Among the agrochemicals, foliar spray of thiourea gave significantly the highest net returns of Rs.19896 ha^{-1} and B:C ratio of 2.47.

अनुक्षेपण

सिंचाई की सीमित परिस्थितियों के अर्न्तगत कृषि रसायनों का गेहूँ की *एस्टीवम* एवं *ड्यूरम* किस्मों की वृद्धि, उपज एवं गुणवत्ता पर प्रभाव

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राजस्थान कृषि महाविद्यालय, उदयपुर में सस्य विज्ञान विभाग के प्रशिक्षणात्मक प्रक्षेत्र पर रबी 2000–2001 में **"सिंचाई की सीमित परिस्थितियों के अर्न्तगत कृषि रसायनों का गेहूँ की *एस्टीवम* एवं *ड्यूरम* किस्मों की वृद्धि, उपज एवं गुणवत्ता पर प्रभाव"** नामक शीर्षक के अर्न्तगत एक परीक्षण किया गया । परीक्षण के निम्नलिखित उद्देश्य थे : (1) गेहूँ की किस्मों की वृद्धि, उपज एवं गुणवत्ता पर कृषि रसायनों के प्रभाव का अध्ययन करना । (2) सिंचाई की सीमित परिस्थितियों के अर्न्तगत गेहूँ की सबसे उपयुक्त किस्म का चुनाव करना तथा (3) गेहूँ की किस्मों की जल उपयोग कार्य क्षमता पर कृषि रसायनों के प्रभाव का अध्ययन करना । प्रयोग परीक्षण के 16 उपचार निग्रहों में चार किस्में (लोक–1, एच.डब्ल्यू. 2004, एच.आई. 8498 एवं ए 9–30–1) तथा चार पर्णीय छिड़काव उपचार (पानी का छिड़काव, साइकोसिल 1000 पीपीएम, थायोयूरिया 1000 पीपीएम एवं सक्सीनिक अम्ल 1000 पीपीएम) रखे गए । परीक्षण का मूल्यांकन यादृच्छिकृत खण्ड अभिकल्पना में तीन पुनरावृतियों के साथ किया गया । फसल की बुवाई 22 नवम्बर, 2000 को तथा कटाई 20 अप्रैल 2001 को की गयी ।

परीक्षण के परिणाम दर्शाते हैं कि *ड्यूरम* किस्म एच.आई. 8498 ने अधिकतम कल्ले बनने के समय कुल कल्लों की संख्या तथा अधिकतम कल्ले बनने, पुष्पन एवं कटाई के समय शुष्क पदार्थ सार्थक रूप से सर्वाधिक उत्पन्न किया । इस किस्म ने परीक्षक किस्म की तुलना में विभिन्न ऋतु जैविकी अवस्थाएं पहले प्राप्त की । यद्यपि *एस्टीवम* परीक्षक किस्म लोक–1 ने कल्ले बनने एवं पुष्पन के बीच की अवधि में फसल वृद्धि दर तथा सापेक्ष वृद्धि दर का सर्वाधिक मान प्रदान किया । एच.आई. 8498 तथा एच.डब्ल्यू. 2004 किस्मों ने सार्थक

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रूप से ज्यादा प्रभावी कल्ले एवं दाने प्रति बाली उत्पन्न किये । दोनो *एस्टीवम* किस्मों लोक–1 एवं एच.डब्ल्यू. 2004 ने *ड्यूरम* किस्मों की तुलना में ज्यादा लम्बी बालियां पैदा की। एच.आई. 8498, एच.डब्ल्यू. 2004 एवं लोक–1 किस्मों के अर्न्तगत ए. 9–30–1 की तुलना में प्रति बाली दानों का भार सार्थक रूप से ज्यादा पाया गया । 1000–दानों का भार सार्थक रूप से सर्वाधिक *ड्यूरम* किस्म एच.आई. 8498 के अर्न्तगत पाया गया । *ड्यूरम* किस्म एच. आई. 8498 ने सार्थक रूप से सर्वाधिक दाना, भूसा एवं जैव उपज (क्रमशः 37.33, 52.50 एवं 89.33 क्विं./है.) उत्पन्न की जो क्रमशः 16.83, 5.71 एवं 10.07 प्रतिशत लोक–1 से, 9.12, 10.80 एवं 10.08 प्रतिशत एच.डब्ल्यू. 2004 से तथा 28.63, 25.41 एवं 26.73 प्रतिशत ए. 90–30–1 से ज्यादा पायी गयी । इसके अलावा दानों एवं भूसे में नाइट्रोजन की मात्रा में, दानों में प्रोटीन की मात्रा में तथा दानों एवं भूसे द्वारा नाइट्रोजन उदग्रहण में *ड्यूरम* किस्म एच. आई. 8498 के अर्न्तगत सार्थक रूप से सर्वाधिक वृद्धि दर्ज की गई । एच.आई. 8498 किस्म में सार्थक रूप से सर्वाधिक जल उपयोग कार्य क्षमता, 20677 रू. का शुद्ध लाभ तथा 2.33 का लाभ : लागत अनुपात प्रदान किया ।

परिणाम दर्शाते हैं कि साइकोसिल 1000 पीपीएम के पर्णीय छिड़काव द्वारा कटाई के समय पौधे की ऊँचाई सार्थक रूप से सबसे कम प्राप्त हुई । जबकि थायोयूरिया 1000 पीपीएम द्वारा पानी के छिड़काव की तुलना में पौधे की ऊँचाई में सार्थक वृद्धि की गयी। इसके अलावा कृषि रसायनों के पर्णीय छिड़काव ने पुष्पन एवं कटाई के समय सार्थक रूप से अधिक शुष्क पदार्थ संचित किया । कल्ले बनने एवं पुष्पन के बीच की अवधि में साइकोसिल ने फसल वृद्धि दर एवं सापेक्ष वृद्धि दर का सार्थक रूप से सर्वाधिक मान प्रदान किया । फसल के उपज गुणों जैसे प्रभावी कल्लों की संख्या, प्रति बाली दानों की संख्या, प्रति बाली दानों का भार एवं 1000–दानों के भार इत्यादि में पानी के छिड़काव की तुलना में कृषि रसायनों द्वारा सार्थक वृद्धि दर्ज की गयी । साइकोसिल, थायोयूरिया एवं सक्सीनिक अम्ल ने पर्णीय छिड़काव के रूप में पानी के छिड़काव की तुलना मे क्रमशः 29.18, 20.34 एवं 11.37 प्रतिशत ज्यादा दाने की उपज प्रदान की । इन कृषि रसायनों के पर्णीय छिड़काव ने पानी के छिड़काव की तुलना में भूसा एवं जैव उपज, कटाई गुणांक, दानों एवं भूसे में नाइट्रोजन की मात्रा तथा दानों में प्रोटीन की मात्रा तथा दानों एवं भूसे द्वारा नाइट्रोजन

उद्ग्रहण की मात्रा में सार्थक वृद्धि दर्ज की । पानी के छिड़काव की तुलना में कृषि रसायनों के अनुप्रयोग से जल उपभोग में सार्थक गिरावट आयी, जबकि जल उपयोग कार्य क्षमता में सार्थक वृद्धि हुई । कृषि रसायनों में थायोयूरिया के पर्णीय छिड़काव ने सार्थक रूप से सर्वाधिक 19896 रू. का शुद्ध लाभ तथा 2.47 का लाभ लागत अनुपात प्रदान किया ।

APPENDIX-I
ANALYSIS OF VARIANCE FOR GROWTH CHARACTERS

Source of variance	d.f.	M.S.S. Germination count	M.S.S. Total tillers	d.f.	M.S.S. Plant height
Replication	11	2.0909	133.3788	2	26.271460
Variety (V)	3	0.2222	819.3889	3	220.06576*
Agrochemical (A)	--	---	---	3	267.58854*
V x A	---	---	---	9	0.14150
Error	33	6.6768	197.4343	30	26.09968
CV%		6.23	8.15		6.23

APPENDIX-II
ANALYSIS OF VARIANCE FOR DRY MATTER AT SUCCESSIVE GROWTH STAGES

Source of variance	d.f.	M.S.S. At maximum tillering	M.S.S. At anthesis	M.S.S. At harvest
Replication	2	0.36868	144.95442	253.4235
Variety (V)	3	23.38863*	881.61421*	2053.7242*
Agrochemical (A)	3	0.50115	1328.36057*	1545.0195*
V x A	9	0.21803	2.15131	2.25206
Error	30	2.64833	60.34586	221.60573
CV%		7.83	4.89	6.92

APPENDIX-III
ANALYSIS OF VARIANCE FOR GROWTH EFFICIENCY PARAMETERS

Source of variance	d.f.	M.S.S.			
		CGR		RGR	
		Tillering to anthesis	Anthesis to maturity	Tillering to anthesis	Anthesis to maturity
Replication	2	2.48868	1.26673	0.000009	0.000002
Variety (V)	3	9.38334*	2.81414	0.000149*	0.000001
Agrochemical (A)	3	33.44113*	0.33900	0.000167*	0.000003
V x A	9	0.12545	0.03146	0.000002	0.000000
Error	30	2.52869	2.08481	0.000027	0.000005
CV%		10.24	33.93	9.15	33.33

APPENDIX-IV
ANALYSIS OF VARIANCE FOR DIFFERENT PHEONOLOGICAL STAGES

Source of variance	d.f.	M.S.S.				
		Days to germination	Days to tillering initiation	Days to booting	Days to heading	Days to maturity
Replication	2	0.333333	0.27083	1.64583	0.14583	6.39583
Variety (V)	3	0.187500	14.91667*	36.91667*	59.61111*	87.18750*
Agrochemical (A)	3	0.076388	1.47222	2.80556	4.27778	1.07639
V x A	9	0.131944	0.52779	3.56481	0.11111	0.68750
Error	30	0.177778	0.91528	3.91250	7.59028	10.17361
CV%		6.86	3.36	3.05	3.69	2.67

APPENDIX-V
ANALYSIS OF VARIANCE FOR YIELD ATTRIBUTES

Source of variance	d.f.	M.S.S.				
		Effective tillers	Ear length	Grains per ear	Grain weight per ear	1000-grain weight
Replication	2	160.3333	0.545208	3.64583	0.007852	2.07813
Variety (V)	3	1037.3542*	10.37722*	210.9097*	0.102346*	80.90972*
Agrochemical (A)	3	1185.1875*	0.92722*	40.24306*	0.049013*	35.35417*
V x A	9	3.928241	0.093333	0.59491	0.000974	0.22454
Error	30	86.31111	0.273430	8.37917	0.012036	3.27813
CV%		7.76	6.69	7.54	6.00	4.03

APPENDIX-VI
ANALYSIS OF VARIANCE FOR YIELD AND HARVEST INDEX

Source of variance	d.f.	M.S.S.			
		Grain yield	Straw yield	Biological yield	Harvest index
Replication	2	2.35451	2.41924	1.67994	3.55056
Variety (V)	3	148.48244*	243.97321*	724.57346*	17.91389*
Agrochemical (A)	3	154.67328*	43.25782*	346.10416*	38.93939*
V x A	9	1.11262	0.01170	1.23708	0.35434
Error	30	5.39755	11.06629	21.76199	3.73740
CV%		7.01	6.95	5.76	4.74

APPENDIX-VII
ANALYSIS OF VARIANCE FOR NITROGEN CONTENT, UPTAKE AND PROTEIN CONTENT

Source of variance	d.f.	M.S.S.				
		N content		N uptake		Protein content
		Grain	Straw	Grain	Straw	
Replication	2	0.00004	0.00048	9.0350	3.36282	0.00173
Variety (V)	3	0.03612*	0.00198*	852.62034*	107.10179*	1.4092*
Agrochemical (A)	3	0.06509*	0.00584*	999.60154*	47.6760*	2.5443*
V x A	9	0.00068	0.00012	5.90028	0.36223	0.0263
Error	30	0.00508	0.00033	21.51509	3.94002	0.19865
CV%		3.69	3.43	7.21	7.77	3.69

APPENDIX-VIII
ANALYSIS OF VARIANCE FOR CONSUMPTIVE WATER USE AND WATER USE EFFICIENCY

Source of variation	d.f.	M.S.S.	
		Consumptive water use	Water use efficiency
Replication	2	68.57297	1.41482
Variety (V)	3	121.98115	29.69089*
Agrochemical (A)	3	1424.04365*	91.36378*
V x A	9	1.81949	0.37448
Error	30	248.07587	3.66697
CV%		8.08	11.15

APPENDIX-IX
ANALYSIS OF VARIANCE FOR NET RETURNS AND B:C RATIO

Source of variance	d.f.	M.S.S.	
		Net returns	B:C ratio
Replication	2	1013969.32	0.01725
Variety (V)	3	82507325.65*	0.95817*
Agrochemical (A)	3	32758859.02*	2.16437*
V x A	9	550767.22	0.00995
Error	30	2958634.64	0.04214
CV%		9.63	10.04

APPENDIX-X
COST OF CULTIVATION AND PRICES USED TO COMPUTE ECONOMICS OF WHEAT

S.No.	Particulars	Unit cost (Rs)	Cost ha^{-1}
(A)	**Common cost of cultivation :**		
1.	Land preparation by tractor (9 hrs)	150/hr	1350
2.	Pre-sowing irrigation (1)	400/irrigation	400
3.	Sowing & Fertilizer drilling (10 mandays)	44/manday	440
4.	Nitrogen (80 kg ha^{-1})	7.5/kg	600
5.	Phosphorus (40 kg ha^{-1})	20.5/kg	820
6.	Isoproturon (0.75 kg a.i. ha^{-1})	168/500g	382
7.	Spray charges (3 mandays)	44/manday	132
8.	Irrigation (2)	400/irrigation	800
9.	Harvesting (22 mandays)	44/manday	968
10.	Threshing + Winnowing		600
11.	Miscalleneous		200
	Total		6692
(B)	**Treatment cost :**		
1.	Varieties :		
(a)	Lok-1 (119.50 kg ha^{-1})	9.0/kg	1076
(b)	HW2004 (108.70 kg ha^{-1})	9.0/kg	977
(c)	HI8498 (127.10 kg ha^{-1})	9.0/kg	1143
(d)	A 9-30-1 (107.60 kg ha^{-1})	9.0/kg	968
2.	Agrochemials :		
(a)	Water spray	---	132
(b)	Cycocel 1000ppm + Spray charge*	415/25g	4282
(c)	Thiourea 1000ppm + Spray charge	320/500g	292
(d)	Succinic acid 1000ppm + Spray charge	500/500g	382

* Spray charge = Rs.132.00 ha^{-1}

APPENDIX-XI
ECONOMICS OF TREATMENT COMBINATIONS

Treatment Combination	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Gross return (Rs ha^{-1})	Total cost (Rs ha^{-1})	Net return (Rs ha^{-1})	B:C ratio
V_1W	30.72	46.66	24770	7900	16870	2.14
V_1C	37.47	48.59	29630	12050	17580	1.46
V_1T	35.06	48.16	27913	8060	19853	2.46
V_1S	32.57	47.65	26135	8150	17984	2.21
V_2W	29.35	46.63	23809	7802	16007	2.05
V_2C	38.43	48.56	30300	11952	18349	1.54
V_2T	35.81	48.13	28436	7962	20474	2.57
V_2S	33.29	47.62	26636	8052	18585	2.31
V_3W	32.16	50.95	26079	7967	18112	2.27
V_3C	41.94	53.06	33072	12117	20952	1.73
V_3T	39.12	52.58	31065	8127	22938	2.82
V_3S	36.12	52.02	28925	8217	20708	2.52
V_4W	24.79	41.22	20238	7792	12447	1.60
V_4C	32.74	43.00	25928	11942	13986	1.17
V_4T	30.43	42.54	24279	7952	16327	2.05
V_4S	28.13	42.09	22637	8042	14596	1.81

Selling price :
Grain = Rs 700/q
Straw = Rs 70/q