WHEAT

Botanical Name: *Triticum* spp.

Family: Graminae

Wheat is world's most widely cultivated food crop and in India is the second important staple cereal food. As a *rabi* season (winter) crop, wheat played vital role in stabilizing the food grain production in the country. It is mostly eaten in the form of *chapaties*. Besides, wheat is also consumed in various other forms such as poories, *dalia*, *halwa*, sweet meals etc. In areas where rice is the staple food, wheat is used in the form of *upma* or *poories.* Wheat is also used for manufacturing of bread, flakes, cakes, biscuits etc.

Wheat contains more protein [8-15% (grain), 8-13% (flour)] than other cereals. Wheat proteins are of special significance. Besides their significance in nutrition, these are principally concerned with providing the characteristic substance 'gluten', which is very essential for backers. Wheat straw is good source of feed for livestock in our country.

Geographic Distribution

Wheat is grown globally in 217 m ha area with a total production of 632 million tonnes. The area remained constant at about 220 m ha in the past 3 decades, however, the production has increased from 355 million tonnes (1975) to the present level owing to enhanced productivity. Though it is grown on largest acreage in India, but the total production is highest in China. The area, production and productivity in major countries of the world and states of India are given below in Table 1 and Table 2 respectively.

Table 1.Major wheat producing countries of world

Country	Area (m ha)	Production (m t)	Productivity (t/ha)
China	21.63	91.95	4.25
India	26.62	72.06	2.71
USA	20.23	58.74	2.90
Russian Federation	22.92	45.41	1.98
France	5.24	39.71	7.58
Canada	9.86	25.86	2.62
Australia	13.77	22.61	1.64
Turkey	9.30	21.00	2.26
Pakistan	8.22	19.50	2.37
UK	1.99	15.47	7.78
Argentina	5.74	14.56	2.54

Country	Area (m ha)	Production (m t)	Productivity (t/ha)
World	**217.07**	**632.59**	**2.91**
Source: FAO Production Year Book, 2004			

Table 2.Area, production and productivity of wheat in important states of India (2004-05)

State	Area (m ha)	Production (m t)	Productivity (kg/ha)
Assam	0.064	0.068	1066
Bihar	2.027	3.263	1609
Chattisgarh	0.097	0.082	853
Gujarat	0.727	1.806	2482
Haryana	2.322	9.058	3901
Himachal Pradesh	0.363	0.684	1890
Jammu & Kashmir	0.248	0.474	1910
Jharkhand	0.063	0.150	2381
Karnataka	0.242	0.179	740
Madhya Pradesh	4.136	7.177	1735
Maharashtra	0.456	1.016	1344
Punjab	3.482	14.698	4221
Rajasthan	2.010	5.707	2839
Uttarakhand	0.394	0.803	2038
Uttar Pradesh	8.999	22.514	2502
West Bengal	0.400	0.842	2103
India	**26.383**	**68.637**	**2602**

Source: Fertilizer Association of India, 2006

Origin and History

Wheat is cultivated since pre-historic times in the world. From all possible records, it seems that its center of origin is South Western Asia. It is believed that Aryans brought wheat grains to India, and since then it is being grown in India. Records from ancient

China show that it is raised there since 2700 BC, and it was also known to Egyptians and inhabitants of Switzerland as early as stone age. The centres of origin of *Triticum* species are given below.

Centres of origin of *Triticum* species

Species (Ploidy level)	Common name	Centre of origin
aestivum (6x)	Bread wheat	Central Asia, North East
dicoccum (6x)	Emmer wheat	Abyssinia
durum (4x)	Macaroni wheat	Near East, Mediterranean region, Abyssinia
turgidum (4x)	Rivet or cone wheat	
monococcum (4x)	Einkorn wheat	Near East
compactum (6x)	Club wheat	Central Asia
sphaerococcum (6x)	Short wheat	Central Asia

Source: Zeven and Zhukovsky (1975) and Hawkes (1982)

Classification of Indian Wheat

Wheat is an annual plant of poaceae family. It belongs to genus *Triticum*. As many as 18 species of wheat have been described and recognized by Percival (1921). The classification of Indian wheats is given below:

Common bread wheat (*Triticum vulgare* Host) (2n = 6x = 42): It is typical wheat of alluvial soils of Indo-Gangetic plains, i.e., Punjab, Uttar Pradesh, Bihar and Parts of Rajasthan.

Emmer or Khapli wheat (*Triticum dicoccum* Schub L.) (2n = 2x = 14): It is believed to be developed from *T. diccoides* Koru (a wild form). It was grown in southern India, i.e., Maharashtra, Tamil Nadu, Karnataka. It is also grown in Spain, Italy, Germany and Russia. DDK 1000, DDK 1029 are important varieties of this group evolved in India and released for general cultivation during 1995-96 and 2006 respectively. It accounts 2% of the total wheat grown in India.

Macaroni or durum wheat (*Triticum durum* Desf.) (2n=4x=28): Suitable for drought conditions or restricted irrigation conditions of Punjab, Madhya Pradesh, Karnataka, Tamil Nadu, Gujarat, West Bengal and Himachal Pradesh. It is also grown in Italy, USA, Canada, and Russia. These are believed to have descended from Emmer. This type of wheat accounts for 12% acreage of total wheat in India.

Triticum durum

Triticum aestivum (2m=6x=42): This type is presently grown in India in almost all the wheat-growing zones. This wheat is introduced in India by Dr N.E. Borlaug of Mexico, and this wheat is frequently called as Mexican dwarf wheat. This accounts for 86% of the total wheat acreage in India.

An atlas has been developed for various quality parameters, and following classes of wheat have been recognised:

(i) Indian Medium Hard Wheat (IMHW) for *chapati* and related products

(ii) Indian Hard Wheat (IHW) for bread

(iii) Indian Soft Wheat (ISW) for biscuit

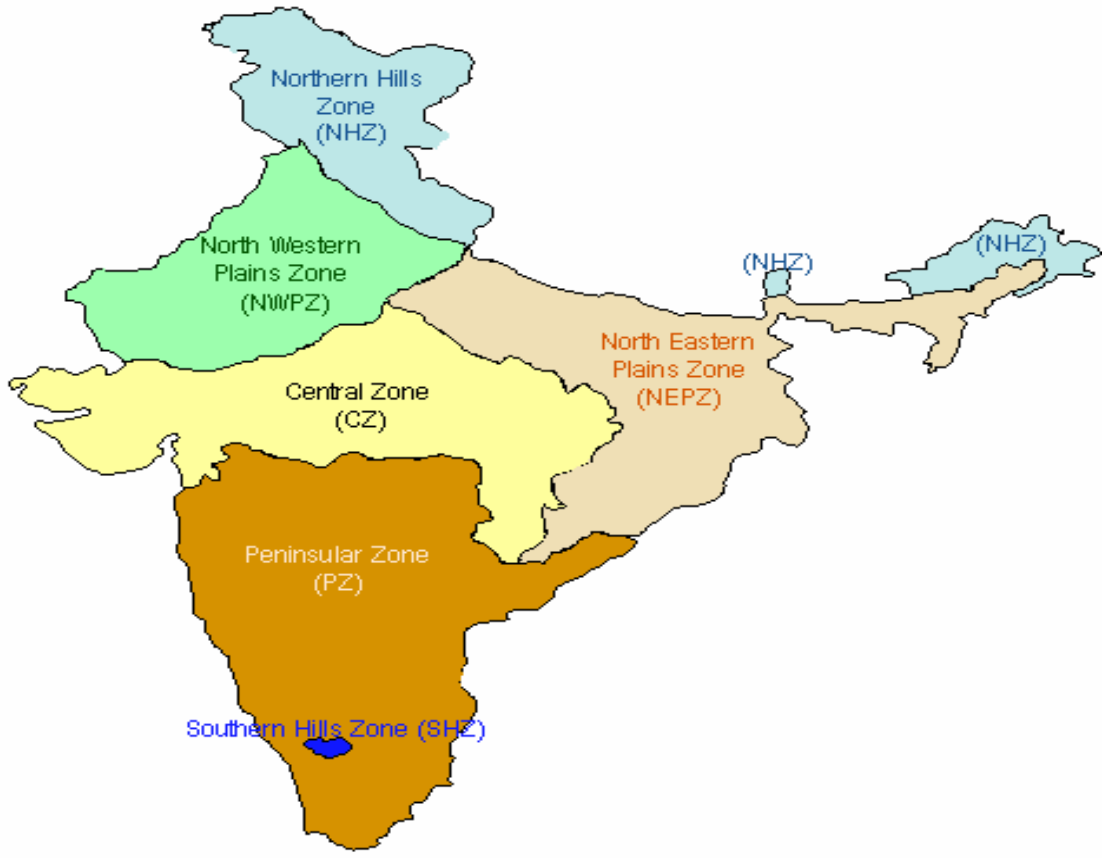
(iv) Indian *durum* Wheat (IDUE) for pasta and traditional products and

(v) Indian *dicoccum* Wheat (IDIW) for traditional and pasta products

Triticum aestivum

Wheat growing Zones in India

The country is divided into 6 wheat zones for the purpose of testing and finding out suitable varieties for each agro-climatic zone.



WHEAT GROWING ZONES OF INDIA

(Source: http://krishisewa.com/krishi/Azone.html)

The North-Western Plains Zone (NPWZ)

This zone covers sub-humid alluvial and arid western plains of Delhi, Jammu & Kathua Districts of Jammu & Kashmir and Una District and Paonta Valley parts of Himachal Pradesh, *Tarai* region of Uttarakhand, Haryana, Punjab, Rajasthan (except Kota and Udaipur divisions) and western Uttar Pradesh (except Jhansi division). It is the major wheat producing zone of the country with mainly *Triticum aestivum* types grown under irrigation from October to April. Of the total acreage(27.7 m ha) under wheat, this zone accounts for 11.1 m ha acreage.

The North Eastern Plains Zone (NEPZ)

This zone comprises humid areas of eastern Uttar Pradesh, Bihar, Jharkhand, Orissa, Sikkim, West Bengal, Assam and plains of North-Eastern states. This region is

characterized by relatively short cool season. *aestivum* wheats are grown exclusively with cropping season spread between November to March/April. This zone has 9.2 m ha acreage under wheat.

Triticum aestivum

The Northern Hills Zone (NHZ)

It consists of humid western Himalayan areas of Jammu & Kashmir (except Jammu & Kathua Districts), Himachal Pradesh (except Una District and Paonta Valley), Uttarakhand (except *tarai* area), Sikkim, hills of West Bengal and North East states. The crop is sown in October and harvested in May/June. On high mountains and valleys, the crop is sown in summer months of April/June and harvested during September to November. In this zone, wheat is grown in 0.8 m ha area.

The Central Zone

It is spread in arid western plain, semi-arid lava plateau, central highland of north India, and sub-humid to humid eastern and south-eastern uplands of Gujarat, south-eastern Rajasthan (Kota and Udaipur divisions), Jhansi division of Uttar Pradesh, Madhya Pradesh, and Chattisgarh. This is predominantly rainfed wheat zone. *Triticum durum* with some *T. aestivum* is cultivated under irrigated conditions. In some parts of Gujarat even *T. dicoccum* are grown. The crop suffers from frost occasionally in Narmada Valley (Tikamgarh) areas of Madhya Pradesh. The crop season is spread between October and March. Wheat occupies 5.0 m ha area in this zone.

The Peninsular Zone

This zone spread in Decan plateau, western Ghats, central highlands and south India in the states of Maharashtra, Andhra Pradesh, Karnataka, Goa and Plains of Tamil Nadu. In this zone *T. aestivum, T. durum* and *T. dicoccum* types are grown under rainfed and irrigated conditions. The cropping season is spread between October to March. Thermo-sensitive varieties are preferred in this zone for cultivation. Wheat is grown in 1.5 m ha area.

The Southern Hills Zone

This zone comprises hilly areas of Tamil Nadu and Kerala along with Nilgiri and Palni hills of southern Plateau with predominant cultivation of *T. aestivum* and *T. dicoccum*. The wheat is grown in 2 seasons i.e., May to September and October to April. Wheat is cultivated in 0.1 m ha in this zone.

Botanical Description of Wheat

Wheat plant can be divided in 2 distinct parts, viz., root system and shoot system.

Root system: There are 2 sets of roots in wheat. The *seminal* or *seedling* roots belonging to embryo, and are produced by the germinating seedlings. It arises at the depth where the seed is planted. As plant growth progresses, this primary root system usually dies, and is replaced by the more permanent secondary root system. The second set of roots is called as

clonal roots, which arises from the basal nodes of the plants and form the compact vegetative mass known as '*crown*'. The entire roots are adventious. The second set forms the permanent root system, while the seminal roots dry after about 30 days of the seedlings emergence.

Shoot system: This system collectively applied to all the visible parts above the ground. It comprises of stems, leaves and inflorescence. A stem and inflorescence may be called a '*culm*'.

- ***Stem****:* The stem of wheat plant is erect, cylindrical, jointed and smooth. In bread wheat, the stems are hollow, except at the nodes where they are solid, but in a few cultivars of Macaroni wheat, the internodes are completely filled with soft pith.
- *Leaves:* The wheat leaves consists of the following 4 parts. *Leaf sheath*: The basal part of the leaf, which encircles the stem and the blade that bends away from the stem. *Leaf blade*: the flattened, parallel veined portion of the leaf. *Ligule*: the membranous outgrowth is called ligule. *Auricle*: lobes of the leaf blade, which extend downward on each side at the junction of the blade and sheath. These are claw-like appendages projecting from the collar of the leaf.
- *Inflorescence:* The inflorescence is known as '*ear*' or '*head*', but its botanical name is spike. Spikelets are systematically arranged and are distributed along the central zig-zag axis '*rachis*'. The spikelets are borne on alternate sides of the rachis, which gives it a zig-zag appearance.
- *Spikelet*: It is composed of flowers called florets. The number of florets in a spikelet may vary from 1 to 5. The florets in each spikelet are enclosed by 2 glumes.
- *Kernel:* Wheat has a '*caryopsis*' type of fruit. The typical wheat kernel is 3 to 10 mm in length and 3 to 5 mm in diameter.

Various Growth Stages of Wheat Plant

Wheat plant passes through various stages of growth, as described below:

1. ***Pre-establishment stages***
2. *Pre-emergence:* Germination of seeds, which produce seminal roots and coleoptiles.
3. *Emergence:* Germinating seeds produce coleoptiles above the soil surface.
4. ***Vegetative stages***
5. *Seedling:* The young plants establish larger root systems in their seedling stage.
6. *Crown root stage:* This coincides with three or four leaf stage of plant.
7. *Tillering:*Plant produces crown & branch out into tillers from their base at soil surface
8. *Jointing:* At this stage, the plant starts elongating when the nodes start developing above the crown node.
9. ***Reproductive stages***

10. *Booting:*In this stage, the upper most leaf swells out into flag holding the spike into it.
11. *Heading:* In this stage, the spike starts emerging out from the leaf sheath.
12. *Flowering:* At this stage, anthesis of florets and fertilization of ovaries take place.
13. ***Post-anthesis stages***
14. *Filling:* After fertilization, the ovaries start elongating in ovules or seed passing through milk, soft-dough and hard-dough stages.
15. *Maturity*: At this stage, the colour of glumes changes and kernels become fairly hard.

Climate

Wheat is grown not only in tropical and sub-tropical zones but also in the temperate zones between 47°S and 57°N latitude from sea level to an elevation of 3,300 m. It can tolerate severe cold and snow and resumes growth with the onset of warm weather in spring. In India, its cultivation is spread between 10°N to 37°N latitudes.

The optimum temperature range for ideal germination of wheat seed is 20-25°C. However, the seed can germinate in the temperature range of 3.5°-35°C. For vegetative growth, 16-22°C is the optimum temperature. Wheat plant requires about 14-15°C optimum average temperature at the time of maturity. Temperatures above 25°C during this period tend to decrease grain weight. Wheat can be grown successfully in those regions where annual rainfall varies from 25 to 150 cm. A well distributed winter rainfall of 15-20 cm is required for rainfed cropping. Rains just after sowing hamper germination and encourage seedling blight. The areas with a warm and damp climate are not suitable for wheat cultivation. Wheat plant requires medium (50-60%) humidity for their growth, but at the time of maturity, crop requires less humidity. Cloudy weather with high humidity and low temperature is conducive for rust attack.

Soils

Wheat, though grown on a wide variety of soils, prefers fertile, well-drained medium textured loamy to clay loams. A good crop of wheat can also be raised in sandy loams and black soils. However, too sandy and poorly drained soils (clay >60%) are not suitable for wheat. Soil should be neutral (6-8 pH) in reaction. Under dry conditions, heavy soils with good drainage are best owing to their better moisture retention properties. Soils with electrical conductivity of saturation extract >6 dS/m and exchangeable sodium percentage >40 are not suitable for economical yield realization. The soil depth should be greater than 25 cm for wheat cultivation.

In India, wheat-growing areas can be mainly divided into 5 soil divisions, (1) the Gangetic alluvium of Uttar Pradesh and Bihar (2) the Indus alluvium of the Punjab and Haryana, (3) the black soil regions of central and southern India comprising Madhya Pradesh and parts of Maharashtra and Karnataka, (4) the hilly regions of the Himalaya and elsewhere, and (5) the desert soils of Rajasthan.

Cultural Practices

Wheat has been under cultivation since time immemorial. But with the introduction of dwarf wheats in India, it is realized that the agro-techniques evolved for tall indigenous wheat varieties do not suit to the growth and development of dwarf wheats. It is therefore essential to be in touch with the day-to-day changes in technical know-how of the improved wheat crop culture.

Land Preparation

Wheat crop requires a well-pulverized, but compact seed-bed for proper germination. In irrigated areas, wheat is usually sown after *kharif* crops like paddy, maize, sorghum, pearl millet, black gram and green gram etc. After the harvest of preceding crop, the land should be ploughed with mould board plough. Where bullocks are the source of power, deep-ploughing followed by 2-3 harrowing or 4-5 inter-cross ploughing with country plough should be done. To retain the moisture in the soil, planking should be done after each ploughing. Avoid powdery seed-bed. Farmers still believe in preparing a powdery seed-bed, but recent technology has proved that if the field does not have much of perennial weeds, more than 2 ploughings are wasteful. Usually 1 ploughing with a soil turning plough followed by harrowing and leveling, if necessary, brings about a good tilth for sowing.

In case where sugarcane, *toria*, pigeonpea etc. are taken as preceding crops pre-sowing irrigation (*palewa*) may be given in the preceding standing crop so that field may become available for its preparation and sowing soon after the harvest of previous crop. In certain areas wheat crop is attacked by white ants and *gujihia* weevil. To protect young seedlings from these insect-pests mix aldrin 5% dust in soil @ 25 kg/ha at the time of last ploughing.

In rainfed areas, field preparation should be done with great care as conservation of moisture is dependent on it. The land is prepared by giving one deep ploughing with mould board plough followed by 2-3 ploughings with country plough and planking. In these areas, ploughing should be done in the evening time and furrows should be kept open whole night to absorb some moisture from dew. The planking should be done after each ploughing early in the morning.

In recent times, with the development of seed drills, "*zero tillage*" sowings are practiced after rice especially. This practice not only economizes cost of land preparation, but also reduces weed menace owing to non-ploughing of the land. The existing weeds may be killed by non-selective herbicides (paraquat, glyphosate) spray.

Manure and Fertilizers

Manures and fertilizers both play a very important role in wheat cultivation. Use of manure improves the general physical condition, structure of the soil and its water-holding capacity. About 10-15 tonnes of well rotten FYM or compost should be incorporated 4-6 weeks before sowing and worked well into the soil. However, manures alone can not meet the high nutrient requirement of crop. It is therefore necessary to supplement manures with fertilizers to realize high yields. A crop of wheat on an average remove 25-9-33-4.7-5.3-4.7 (81.7) kg/ha of N-P_2O_5-K_2O-S-Ca-Mg for every tonne of grain produced.

Indian soils are generally deficient in N, but the status of P and K varies from place to place depending on native nutrient content and previous fertilization history of field.

Fertilizer dose for wheat should therefore be related to the fertility status of the soil as indicated by soil test. In case soil test recommendations are not available, the general guidelines for fertilization of high-yielding dwarf varieties grown under different agro-climatic conditions laid down by the All-India Coordinated Wheat Improvement Project should be followed.

Nutrient requirement of wheat (irrigated area)

Variety	Nutrient quantity (kg/ha)		
	N	P_2O_5	K_2O
Irrigated *Deshi* and Dwarf varieties (Late sown)	70	40	40
Irrigated Dwarf varieties (Timely sown)	110	50	40
Un-irrigated / rainfed *Deshi* varieties	25	20	15
Un-irrigated / rainfed Dwarf varieties	50	30	20

Method and Time of Application of Fertilizers

The response of dwarf wheat to applied N ranges between 35-45 kg grain/kg of N in comparison to 5 kg grain/kg of N in case improved tall varieties. It has also been observed that lodging susceptible cultivars and rainfed dwarf cultivars respond up to 40 kg N/ha, but the economic dose of N for dwarf wheat under irrigated condition is 100-120 kg/ha. Under normal soil conditions, both P and K give best response up to 40 kg/ha. In most of the light-textured soils, Zn has been a key element for getting higher yields. Zinc sulphate @ 20-25 kg/ha should be applied in soil before last cultivation in these soils.

The rate of fertilizer application also depends upon the preceding crop, viz. after an exhaustive crop like pearl millet and sorghum, a dose of 120-150 kg N/ha is required, while after fallow or any legume crop or heavily fertilized crops like hybrid maize, potato etc., an application of 80-100 kg/ha N is quite sufficient. In medium and heavy soils, nitrogenous fertilizers should be applied in 2 splits i.e., ½ at the time of sowing and the remaining ½ at the first irrigation. In sandy soils, top-dressing should be made in 2 or 3 installments if heavy dose of N is to be applied. Under rainfed conditions, full dose of N should be placed into the soil before sowing. Calcium ammonium nitrate (CAN) and ammonium sulphate are the best sources of N along with super phosphate/ Di-ammonium phosphate (DAP) for basal application under neutral soil reaction, and urea for saline reaction. Top-dressing should always be done with urea.

Full dose of P and K should be applied at the time of sowing. For wheat, phosphate fertilizer must contain 50% of total P as water-soluble and the remaining as citrate-soluble. This is especially important for neutral and alkaline soils. In acid soils, use of basic slag or rock phosphate may be more profitable than super phosphate or DAP, because cost/unit P is much less in the former than the latter.

Muriates of Potash and Potassium Sulphate are the only potassic fertilizers presently available in the market. Both are equally good for wheat.

Varieties:

The varieties recommended for different zones are listed below. In recent times, there has been emphasis on development of hybrids. Directorate of Wheat Research, Karnal has developed hybrids with 25-29% heterosis. The hybrids HM 99495 and HM 99104 showed a standard heterosis of 10.7% and 7%, respectively over locations during *rabi* 2002-03. Hybrids (HM 00504, HM 11139, HM 11049, HM01903 and HM01899) were found superior in quality (protein %, hectoliter weight, sedimentation value, extraction rate, loaf volume and bread quality) to the varieties.

Wheat varieties recommended for different zones of India

Zone	Irrigated-Timely sown	Irrigated-Late sown	Rainfed	Sodic soils/ other conditions
NWPZ (North western Plains zone)				
Bread wheat	PBW 343, PBW 502, WH 542, UP 2338, WH 416, DH 2687, CPAN 3004, Raj 3077, HD 2281, HD 2478, HD 2204, HD 2428, HD 2329, HD 2177, WG 357, WG 377, Sonalika, UP 2003, UP 2338, HD 2285, Arjun (HD 2009), WH-147, WL 711, WH 157, PDW 34, PBW 17, PBW 154, PBW 299, PBW 215, PBW 233, Jairaj (JNK HW 185), Lok-1, Raj 1114, UP 368, PBW 226, DLW 5023, CPAN 1676, CPAN 3004 (Sangam), UP 319, HUW –12 (Malviya 12)	PBW 373, UP 2338, UP 2425, Raj 3077, Raj 3765, PBW 226, HD 2285, Raj 3777, HD 2402, HD 2270, Sonalika, HD 2307, UP 2121, , PBW 234, HUW 234, Swati, HD 2329, UP 115, PBW 138, HP 1209, WH 291	PBW 299, WH 533, PBW 396, PBW 175, PBW 65, C-306, Pratap (HD 1981), K 68, Kundan, UP 2113, K 8962, WH 331, WL 410, WL 2265, PBW 229, WL 175, Mukta (HI 385), Meghdoot (HI 748), Sujata, DL 153-2, D 134, IWP-72, K-65, K-72, WL 2264, WL 410, WP 72, PBW-117	Raj 3077, KRL-19, WH 157, Sonalika, HD 2380, K-1410, WH 157, HD 2285, HS 86, HS 208, UP 1109, VL 401, VL 421, VL 616, CPAN 1982, CPAN 1996
durum	PBW 34, PDW 215, PDW 233, WH 896		A 9-31-1	
NEPZ (North Eastern Plains zone)				
Bread wheat	DL 784-3, HD 2733, HD 2824, HUW 468, HP 1731 (Deva), HP 1761, K 8804, K 9107, NW 1012, PBW 443, HD 2402, Janak, Poorvi or (K-7410), K-9006, UP 262, HP 1102, HUW 206, HUW 55, DL 784-3, HUW 205, HP 1102, UP 2003, Saniak, HD 2281, Sonalika, K.purvi, K-68, WL 711, Malviya 12, PBW 154, Malviya 55, PBW 343, K 0307	DBW 14, DL 784-3, HD 2643, HP 1633 (Sonali), HP 1744, HW 2045, NW 1014, NW 2036, HP 1209, HUW 234, HD 2285, Raj 3777, Raj 3765, HD 2402, HD 2307, Sonalika, K 8027, K 9006, UP 115, HP 1133, UP 1209, HUW 213, HP 1100, NP 2121, HD 1982, HD 225, K 8020, PBW-154, PBW 226, Malviya 213, HD	HDR 77, K 9465, K 8027, C 306, K 8962 (Indra), K 65, HDB 77, Janak (HD 1982), Pratap, K 8804, IWP 72, HDW 234, WL 410, WL 2265, DL 155-2, W 175, HDR 77, K 68, Kalyansona, HP 852, K 72, NP 401	Raj 3077, KRL 19, KRL 1-4, Job 666, K 1410, Sonalika, UP 1109, VL 616

		2385, Shera		
Central zone				
Bread wheat	DL 803-3, GW 273, GW 190, GW 322, HI 1077, HD 2236, HD 2381, HD 4530, Lok-1, Jairaj, HD 2389, WH 147, HI 8318, J 405, Raj 1555, Raj 911, GW 366	DL 803-3, DL 788-2, GW 173, MP 4010, Swati, J 405, HD 2285, Raj 3777, Raj 3765, HD 2402, HD 2327, Sonalika, Lok-1, J1-104, Raj 4083	HW 2004, JWS 17, HI 1500, C-306, Sujata, HY 65, Narbada 4, Mukta (HI 365), Meghdoot (HI 748), Narmada 41, Narmada 1112, PDW 215, JU 12, NP 832, HP 852, CPAN 3004, Kalyansona	Raj 3077, KRL-19, KRL 1-4, Job 666
durum	HI 8331, HI 8498, Raj 1555, HI 8381		HD 4672, A9-30-1	
dicoccum	DDK 1001, DDK 1009, DDK 1029			
Peninsular Zone				
Bread wheat	DWR 162, MACS 2496, GW 322, DWR 195, HD 2501, NIAW 34, Raj 4037, HD 2380, MACS 2446, AKW 1071, HD 2189, DWR 39, UP 215, Malavika (HD 4502), DWR 162	K 9644, HUW 510, DWR 195, HD 2501, NIAW 34, Lok 45, HI 977, HD 2610	HD 2781, K 9644, NI 5439, N 5749, C 306, NI 747-19, MAC 59, A 206, HW 657, A 624, Meghdoot, Mukta	KRL 1-4, Raj 3077, KRL 19, Job 666
durum	DWR 1006, MACS 2846, HD 4502	N 59, MACS	NIDW 15, N 59, MACS 1967, Bijaga yellow	
dicoccum	DDK 1001, DDK 1009, NP 200			
North Hills Zone				
Bread wheat	VL 738, VL 804, HS 240, HD 2380, UP 1109, Girija, Sonalika, HD 208, HS 204, Shailja, HS 86, VL 404, HD 2286, HS 208, VL 421, VL 616, CPAN 1996 **High altitute summer season:** HPW 42, HS 365, HS 375	HS 295, HS 420, UP 1109, Sonalika, HS 86, HS 207, VL 404	VL 738, HPW 42, HS 365, VL 804, VL 832, VL 375, HS 295, HPW 42, HS 240, HD 2360, HS 207, VL 404, VL 421, VL 401, HD 2204, HD 2418, UP 1109, HD 2177, HD 2380, HB 208, WL 411, C-306, Kalyansona, Radhey,WL2265, Girija, HS 86, HS 208 **Early sowing:** HS 277, VL 829, VL 616	

Southern Hills Zone				
Bread wheat	HUW 318, HW 1085, HW 2044, HW 971, HW 741, HW 972, NP 200 (Samba), UP 215, HD 2135	HW 971, HUW 318, HW 2044, HW 1085, MP 200, Raj 3765, PBW 373, Halna	HW 971, HUW 318, HW 1085, HW 2044, MP 200	HW 971, HW 1085, HW 2044, HUM 318, KRL 19, KRL 1-4
dicoccum	NP 200, DDK 1001, DDK 1009, DDK 1029			

Seed and Sowing

Selection of seed: Only healthy seeds of right cultivar suitable for a particular locality should be selected for sowing. The seed should be purchased from a reliable source. It is advisable to use certified seed only. If seed is not treated earlier, treat with thiram, agrosan GN or vitavex @ 2.5 g/kg seed.

Time of sowing

Time of sowing has a marked influence on the yield of wheat. It depends mostly on soil temperature, irrigation facilities and duration of wheat cultivars. The normal time for sowing of high-yielding cultivars in irrigated areas beings in early November. Long and medium duration cultivars like UP 368, UP 2003, Arjun, WG 357, WL 711, HD 2204 etc. should be sown in the first fortnight of November, while short duration cultivars (120-125 days) like UP 115, UP 262, etc. in the second fortnight of November. Under specific situations, wheat is also sown in December. In late-sowing, short duration cultivars should be sown because there is comparatively less reduction in their yields as compared to late and medium duration cultivates. Delay in sowing beyond November by each day causes a reduction of 5 kg/ha/day in north-eastern parts of the country, and 41.6 kg/ha/day in north-western and central parts of the country. For wheat crop sown in January after *toria*, sugarcane, potato etc., thermo-insensitive short duration cultivars needs to be used. This time of sowing has least productivity in all wheat zones. Rainfed wheat is sown early, from mid October to first quarter of November.

Seed Rate

Seed rate varies with cultivar used depending upon its seed size, moisture content in the soil, germination percentage, tillering ability, time of sowing and method of sowing. Usually, a seed rate of 100 kg/ha is sufficient under favourable conditions of normal sowing. In case where seed is to be sown by dibbler, a seed rate of 25-30 kg/ha is sufficient. Under late-sown conditions, seed rate should be increased to 125 kg/ha. Similar seed rate is required for crop sown by *pora* / *kera* methods. For broadcast sowing 150 kg/ha seed are required. Furrow Irrigated Raised Bed (FIRB) system requires 70-80 kg/ha seed.

Spacing

For normal sown crop, a row spacing of 22.0-22.5 cm is recommended. In late sown crop, a closer spacing of 15-18 cm should be adopted.

Depth of Sowing

Depth of sowing is an important aspect in dwarf wheat cultivation. The coleoptile length of high-yielding Mexican cultivars is about 5 cm. Therefore, seeds of these cultivars should not be covered by more than 5 cm soil to ensure uniform and good germination. Seeds of semi-dwarf cultivars could be sown at the depth of 5-6 cm, but the seeds of three gene dwarf cultivars should not be sown deeper than 4 cm. Similarly, in late-sown crop, seeds should be placed shallow (4 cm deep), as deep sowing delays the emergence of seedlings by 2-3 days and heading by a week.

Methods of Sowing

Wheat is sown on a well prepared seed bed or without land preparation by following methods:

- *Broadcast*: This is the primitive method of sowing and despite of several drawbacks, it is still widely practiced. The seeds are broadcast on a well prepared seed bed and then harrowed to cover the seed with a thin layer of soil. The seeds placed on soil surface are eaten away by birds. Further, the seeds with poor or in loose contact with moist soil do not germinate. This results in poor germination and plant stand. To compensate these losses, use of 25% higher seed rate is recommended.
- *Behind the plough*: This method consists of dropping seeds by hand into the furrow opened with a country plough directly (*kera* method) or through a *pora* or *nai* or *hazara* a special attachment (*pora* method). In this method, seeds are placed at a depth of 5-6 cm for satisfactory germination. It is widely adopted by the farmers.
- *Drilling*: In this method, seed is sown with the help of a seed drill or seed-cum-fertilizer drill. The seeds are dropped at uniform depth resulting in optimum germination. The seed rates can be altered depending on the need based on time of sowing, soil moisture etc.
- *Dibbling*: In this method, sowing is done with the help of a small implement "Dibbler" i.e. a wooden or iron frame with pegs. The frame is pressed into a well prepared field and lifted. One to two seeds are dropped by hand in each hole. Despite of its more time and labour requirements for sowing, the method proves best where seed availability is limited.
- *Zero till Sowing*: For timely wheat sowing after rice harvest and also to reduce *Phalaris minor* and *Avena sativa* menace with normal land preparation, seeds are drilled into soil without land preparation. It saves cost on land preparation and reduces weed menace especially germination of *Phalaris* and *Avena* sp. It is widely adopted in north-west plains zone (Punjab, Haryana, Western Uttar Pradesh). Zero till seed drills have been developed and refined at Pantnagar and Ludhiana.
- *FIRB System*: Furrow irrigated raised bed (FIRB) system of planting developed in Yucatan Valley of Mexico is being adopted by farmers only recently. In this method, raised beds (37.5 cm) alternating with furrows (30 cm) are prepared and 2-3 rows of wheat are planted on the bed. The crop is irrigated in furrows. An economy in water with similar wheat yields is the main reason of its adoption.
- *Bi-directional sowing*: In this method, half of the recommended seed and fertilizer are sown in one direction (length-wise) and the other half in other direction (width-wise) followed by light planking. The seeds are sown in rows 20-22 cm apart at a

shallow depth of 4 cm. This method of sowing has been found to yield higher than one direction sowing.

Irrigation

Of the total acreage of wheat, 88.1% is irrigated. The crop requires 45 cm of irrigation water, which may vary with type of soil, variety grown etc. The critical stages of irrigation in dwarf wheat are given as follows:

The first irrigation is applied at the time of crown root initiation (CRI) stage. In timely sown wheat, first irrigation is given between 20-25 days after sowing (DAS). The second irrigation is applied between 40-45 DAS, which coincides with tillering stage. Third irrigation is provided at late jointing stage between 65-75 DAS. The fourth irrigation is given at the flowering stage between 90-95 DAS. The fifth and sixth irrigations are applied at milking stage (110-115 DAS) and dough stage (120-125 DAS) respectively.

In wheat, time of irrigation is more important than number of irrigation. If water is available for one irrigation only, it should be given at CRI stage. Where water is available for two irrigations, it should be applied at CRI and flowering stages. The crop should be irrigated at CRI (21 DAS), late jointing stage (65 DAS) and milking stage (105 DAS) in case of availability of water for three irrigations. If water is available for 4 irrigations, it should be provided at all critical stages except jointing and dough stages. Similarly, where water is available for 5 irrigations, it should be provided at all critical stages, except dough stage.

In tall *desi* wheat varieties, 1 to 3 irrigations are given. First irrigation at 20-25 DAS, second irrigation at 60-65 DAS and the third and final irrigation at 90-95 DAS.

Irrigation by border strip method is ideal for wheat. Under light soils, sprinkler irrigation is promising.

Since moisture is the most limiting factor for a rainfed crop, the following cultural practices should be adopted for conserving the maximum moisture in the soil.

- Levelling of land and raising the bunds around the fields before the onset of rains.
- Plough the fallow fields occasionally during *kharif* and keeping them weed free.
- Spreading the locally available mulching material *Basooti* or any other leafy matter in the standing maize crop or in the fields kept fallow during the last week of August.
- Start the preparatory tillage soon after the harvest of *kharif* crops.

Weeds and Weed Control

In wheat, initial 30-40 days are critical so far as the crop-weed competition is concerned. Uncontrolled weeds depending on intensity and duration of competition may reduce the wheat productivity by 10-40%. Wheat field is generally infested with both grassy and non-grassy weeds.

- *Grassy weeds:* The grassy annual weeds include *Phalaris minor* (canary grass), *Avena ludoviciana, A. fatua* (wild oats), *Polypogon monspiliensis* (loombar grass), *Lolium temulentum* (rye grass) and *Poa annua* (Blue grass).

- *Non-grassy annual weeds*: The major weeds include *Chenopodium album* (*bathua*), *Fumaria parviflora* (*jangli gazar*), *Anagallis arvensis* (*Krishna neel*), *Melilotus alba* (white *senji*), *Melilotus indica* (yellow *senji*), *Vicia sastiva* (*rari*), *Circium arvense* (*kateli*), *Lathyrus aphaca* (*chatri*) and *Medicago denticulata* (*jangali rijhaka*).
- Besides above, the perennial weeds *Convolvulus arvensis* (*hirankhuri*), *Cyperus rotundus* (*motha*), *Cynodon dactylon* (*doob* grass) also grow in wheat causing enormous yield losses.

Phalaris and *Avena* sp. grassy weeds menace has increased with the introduction of dwarf wheats. Both these weeds germinate along with wheat crop and escape hand weeding owing to similar morphology. The differentiating feature of these weeds and wheat in the absence of auricles in both the weeds. In *Phalaris*, the junction of leaf sheath and blade is hairy, while no such hair is found in *Avena*. Further, the ligules are serrated in *Avena*, while non-serrated in *Phalaris*. The menace of *Phalaris* minor is of greater concern in rice-wheat cropping system. In certain locations, the intensity of *P. minor* may be as high as 300-700/m^2. On an average, each plant of *P. minor* produces 300-460 seeds/panicle.

In wheat, weeds are effectively controlled by two hand-weedings / hoeings, first one 25-30 DAS and the subsequent 40-50 DAS. Herbicide usage is very high for weed control in wheat. For control of broad leaved weeds, spray of 2,4-D ethyl ester @ 0.4 kg/ha in 700-800 litres of water at 35 days stage is recommended. Its spray earlier than this stage causes ear head malformation leading to uneven seed size. Monocot weeds can be effectively controlled by spraying of isoproturon @ 1.0 kg/ha or metoxuron or methabenzthiazuron @ 1.5 kg/ha at 30-35 DAS. Pre-emergence application of pendimethalin @ 1.0 kg/ha also provides broad-spectrum weed control.

Cropping Systems

Mixed cropping of wheat with mustard, gram, linseed is common in most of the areas of wheat-growing belt. Now-a-days intercropping with autumn sugarcane (4-5:1) and potato is also becoming popular in some of the parts of northern India. Intercropping of wheat with linseed / pea / gram / lentil in 4:2 ratio and with mustard in 8:2 ratio are also practiced.

With the development of short-duration and photo-insensitive varieties of various crops and assured irrigation, a series of cropping sequences with wheat as one of the main crops have been developed. The flexibility in sowing time of high yielding dwarf varieties of wheat and the possibility of raising a successful crop of late sown wheat provided good opportunities for the adaptation of many promising wheat based cropping systems in assured irrigated areas. Some of the important crop rotations are:

Sorghum or maize-*toria*-wheat-green gram	Pigeonpea-wheat-black gram
Pearl millet-wheat-green gram	Paddy-wheat-cowpea or black gram
Soybean-wheat-green gram	Maize-*toria*-wheat-green gram
Paddy-wheat-green gram/ blackgram	Maize-potato-wheat-cowpea/mungbean

Harvesting and threshing

Wheat crop is usually harvested when the grains become hard and the leaves become dry and brittle. The maturity period depends upon whether crop is grown under rainfed or

irrigated conditions. The maturity period of crop may also vary from zone to zone and also with the variety used. In general, the harvesting periods in different zones are:

Wheat harvesting periods in different zones

Wheat growing zones	Time of harvesting
NEP Zone	Starts from latter part of March and continues till mid April
NWP Zone	Second fortnight of April
Central Zone	End of February to March
Peninsular Zone	Second fortnight of February to beginning of March
Hilly Zone	May-June

The harvesting of crop is mostly done by sickle. However, in recent times combine harvesters are also being used in parts of Punjab, Haryana, western Uttar Pradesh and other northern states. When combine harvester is used, the grain should not contain >20% moisture. Combine can do harvesting, threshing and winnowing of crop in single operation.

After harvesting the crop by hand, it is dried for 3-4 days on the threshing floor and then threshed by bullocks or olpad thresher attached to bullocks. Now-a-days power driven stationary threshers are becoming more popular because these are easy in operation and lesser time consuming.

Yield

By adopting improved technology, the crop may yield 5-6 t grain and 7-8 t straw/ha from dwarf wheat varieties under irrigated conditions. Under rainfed conditions 2-2.5 t grain and 3-3.5 t straw/ha may be obtained. *Deshi* tall wheat varieties usually give 2-3 t grain and 6-7 t straw/ha may be obtained.The yield attributes (range) of wheat is given below:

Attributes	Value
Tillers/m^2	230-340
Grains/spike	42-58
1,000 seed weight (g)	36-50
Protein (%)	10-12
Fat (%)	1.5
Fiber (%)	1.2